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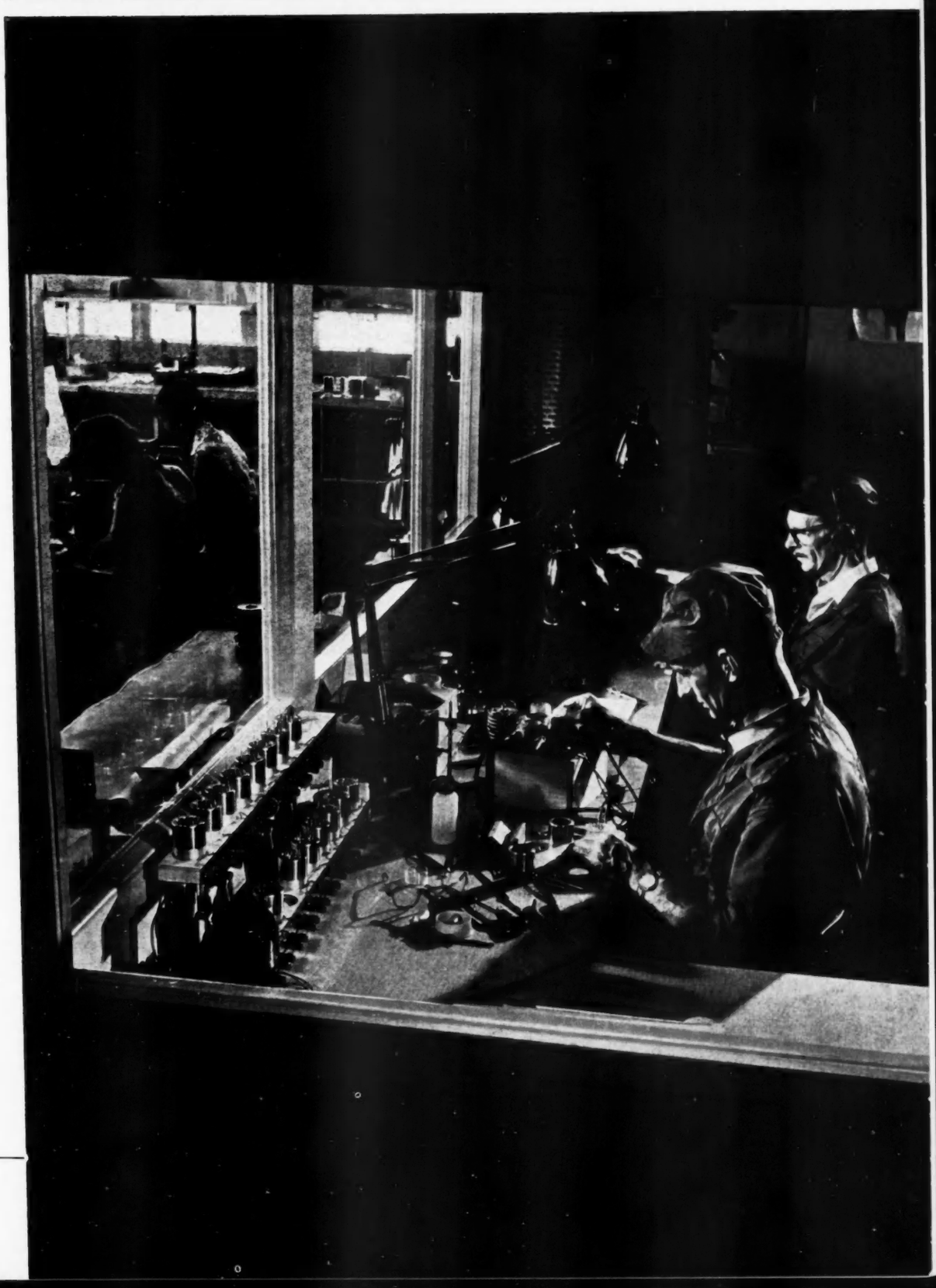

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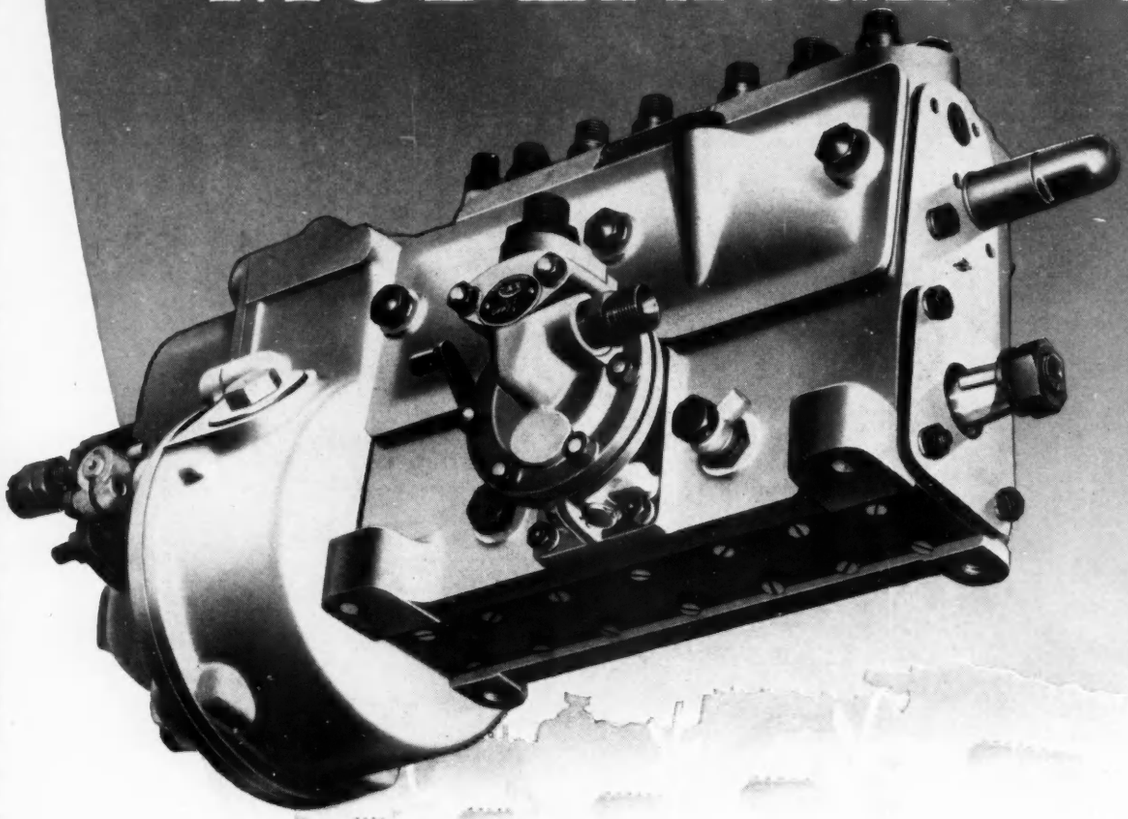

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The Process Calls the Tune

SOME theorists in management methods have for long been proclaiming that their principles are applicable to all types of organisation—from an army to a fried fish shop. While there is no doubt that the understanding of certain elementary principles of human behaviour can be of assistance in any personal relationship, whether of collaboration or control, there has been little evidence based on solid research that anything approaching a complete theoretical system of management has yet been proved valid.

This is not very surprising to those who have experienced, either in industry or in public administration, the enormous variety in purpose, size and complexity of modern organisations. Nevertheless, some similarity in management structure might be expected in manufacturing firms performing similar tasks. That this similarity is based on the techniques of production, and not on the type of industry or size of firm, is the interesting conclusion of a recent study for the Department of Scientific and Industrial Research by Miss Joan Woodward, the results of which have now been published in a booklet, *Management and Technology* (HMSO, price 2*s* 6*d*).

Too much management theory has been based on the experience of large mass-production concerns, chiefly in the engineering industry, and it appears that it is only in these that success follows adherence to the organisational rules. The most appropriate structure of management is that which most successfully furthers the objectives of the firm and these vary greatly. Management ratios change as engineering becomes more complex and as it advances from unit to mass, and from mass to process, production. Not all ratios, however, continue to move in the same direction as engineering advances. Labour costs decrease, the proportion of indirect labour grows and a larger proportion of professional staff is employed on production. But organisation is more flexible at the technical extremes of production method; duties and responsibilities being less clearly defined and the amount of written, as opposed to verbal, communication is less than at the intermediate, mass-production stage. Specialisation between the functions of management is more frequently found in mass production than in unit or process production, where supervisory and technical functions tend to be combined.

Process production is being increasingly applied to the manufacture of discrete solid articles such as canned goods and millboard and, to a limited extent, has been introduced into the manufacture of motor cars and other durable consumer goods. Under the popular title of " automation " this has conjured up frightening pictures of men as the slaves of machines. It is therefore encouraging to learn that human relationships were better both in unit and process-production firms than in mass production. This arises out of the lower pressure exerted at all levels of the industrial hierarchy and the higher quality of relationships, based on technical necessities, between supervisors and subordinates. In the process industries, decision making is a more rational procedure and, therefore, can be more safely delegated. The senior executive is then more free to undertake the important social duties of the head of a large organisation and to make the relatively few decisions dependent on value judgments. Decisions about people, accordingly, tend in process industries to be taken at a higher level.

The extraordinary conclusion of this study is that where men are controlled by the needs of the process they are happier than when subject to the spur of human supervision. This is obviously not the same as domination by the machine or the conveyor belt in the manner of Charlie Chaplin's " Modern Times," for in process work continuous observation and judgment is required and production itself is generally on a high scientific plane.

Social scientists have for long demonstrated the fact that in any establishment there will always be an informal organisation, growing spontaneously out of human needs, as well as the formal organisation created by management. If these are in conflict, it is likely that there will be tensions and performance will be less than the best.

Research of this type comes too little and, in one way, too late. The teaching of management subjects in universities and technical colleges has grown rapidly in recent years, without any clear principles to guide those who draw up syllabuses. There is a danger that immature students, especially those educated in the physical sciences, will take as scientific law the principles of administration on which much management education is based. Perhaps the best way to avoid this danger would be to let management students occupy themselves in some research of this kind. This, together with the comparative study of contrasting firms as practised, for instance, at Brunel College of Technology, would ensure a rational, if sceptical, approach to the problems of management which they are likely to meet in their industrial lives.

Cover Picture.—*Synchronous converters are basically single-pole double-throw switches operating continuously at mains frequency, converting small direct voltages into alternating signals for easy drift-free amplification. The picture shows converters being assembled, tested and calibrated in an air-conditioned room before being sealed in dust-proof cans.*

(*Nurnberg photograph for* ENGINEERING)

* * *

Plain Words

People who try to put things over on me make me mad. The world seems full of crafty talents—political spellbinders skilled at innuendo and deceptive epigram; advertising men who keep themselves ignorant of their product to give them scope in praising it; quacks of all professions, brilliant and imaginative in prescription, but incapable of diagnosis. Words are generally their medium, deft, plausible, inconsequential words, put over with a verbal sleight of hand.

But sometimes it is difficult to distinguish between the charlatan and the honest practitioner, tempted by the jargon of his calling. All disciplines have their secret languages, by which the initiate may be distinguished—languages that may sometimes even afford a means of clear unambiguous communication. But occasionally I wonder where precise expression ends and Beachcomber begins. Maybe, in the words of a rapporteur at a recent international conference, " the divergencies between the two . . . are common to both."

The other day I was reading what appeared to be an authoritative book on human relations, a subject in which there is a need for clear straightforward thinking, and came upon the following inscrutable passage. " Theorem 3-1. If the compatibility of one dyad, y_1, is greater than the compatibility of another dyad, y_2, then the members of y_1 are more likely to prefer each other for continued personal contact ". I looked at it and looked again. A dyad, I discovered, was a couple of people. After a little thought, I realised what was meant: some people get on better than others. I think it is a pity that a study which offers so much promise and may have so many sensible things to say should be obscured by pseudo-scientific verbiage at a time when even the responsible workers cannot agree on the proper terms to use.

Doctors probably have good reason to call heart trouble a cardiac complaint and engineers are not without their verbal foibles. Even ENGINEERING sometimes nods, though no doubt only in the interests of precision. The information that " a flat belt conveyor carries the broke to the back side where it is fed continuously into a screw conveyor and then into the couch pit " may be gibberish to the layman; but to the specialist it represents a simple and explicit statement. No-one is trying to blind anyone with science. Less forgivable is the verbal candy floss that has no substance. Perhaps I'm rather prone to that myself—an empty capricornucopia of words.

CAPRICORN

Weekly Survey

Good Show at Montreal

The Commonwealth Trade and Economic Conference which ended at Montreal on 26 September had the double virtue of being a success and being seen to be a success. The final communiqué from Montreal could list an impressive range of achievements.

So far as trade was concerned, the common objective of freer trade and payments was emphasised, dollar restrictions were deplored, the United Kingdom announced a number of useful reductions in import restrictions and Canada undertook to bind low duties on certain goods from the United Kingdom and Australasia. The need for the European Common Market and the Free Trade Area to be " outward-looking " (an enigmatic phrase) was emphasised. It was recognised that obstacles should not be put in the way of the export of manufactured goods from underdeveloped members of the Commonwealth, and note was taken with some indignation of the efforts of the Sino-Soviet group of countries to sell goods to the West, especially commodities, at disconcertingly low prices. It was agreed to examine commodities subject to wide price fluctuations one at a time to seek remedial action. It was agreed that sterling should be made convertible as soon as conditions permitted, and there were some practical gestures towards helping development in underdeveloped countries.

The guarded references to the problem of stabilising commodity prices hide a good deal of protectionist thinking. The good wishes sent to the Free Trade Area and the agreement on helping the manufactured exports of underdeveloped countries in the Commonwealth does not suggest that the conference dedicated itself to the principles of free trade. Beneath the surface there still lurks a great desire in some members of the Commonwealth to fabricate a structure of high and stable prices behind which primary producers with a high standard of living can live in peace.

Commonwealth Catalysts

The Commonwealth Economic Conference at Montreal was, in a sense, only a visible and passing symptom of the economic forces which are constantly at work to bind or loosen the Commonwealth's ties: not without intent, the Montreal conference coincided with the release of a flow of literature on economic problems.

A selection of these in one week consists of *Britain, The Commonwealth and European Free Trade* (from Britain in Europe Limited, prepared by the Economist Intelligence Unit); *Freedom and Independence for Nigeria* by Obafemi Awolowo, a prominent Nigerian politician; *The Federation of Nigeria* (from the Central Office of Information); *Economic Development in the Commonwealth* (also from the COI); and *The Pattern of Commonwealth Trade* (COI).

A reading of the publications, as well as the official communiqués from Montreal, leaves two main impressions. The first is that trade and development are not the same thing and are not necessarily concomitants. Development can be used to influence trade adversely. To put it bluntly, it may be a temptation to the wealthier members of the Commonwealth to offer finance and technical aid rather than accept cheap imports of commodities and manufactured goods from the underdeveloped parts of the Commonwealth. There is already a faint flavour of this in the Colombo Plan and the trading policies of certain countries. If it goes too far there may be serious tension among the senior associates.

The second impression is the pace at which the Commonwealth's economic problems change. Some of the Dominions have already relinquished in spirit the idea of imperial preferences (though naturally they hesitate to throw away overtly its advantages and bargaining power) in favour of closer economic relations with Western Europe. At the moment, too, the export performance of the Sterling Area (outside the United Kingdom) is severely impaired by low world commodity prices. The United Kingdom is the stable member with a good export record as well as being the banker for the others. Next year, the Dominions may be the big foreign-currency earners. Significantly, Ghana continues to be an important dollar earner. Nigeria, some way behind politically, but travelling fast towards dominion status (or independence) must view Ghana's position with envy.

New Order of Battle

The reorganisation of the Admiralty's Material Departments under the Controller of the Navy was announced in December of last year and was completed on 1 October by the setting up of the new Ship Department. The work of the Controller's old style departments has now been reorganised into four large material departments each headed by a Director General, and a small group of scientific departments headed by the Chief of the Royal Naval Scientific Service. The four large material departments are the Ship Department, the Weapons Department, the Aircraft Department, and the Dockyard and Maintenance Department.

The scientific departments are broadly responsible for basic research and development, the provision of scientific staff and advice to the material departments and the planning and co-ordination of Admiralty research programmes. Each of the material departments is divided into a number of divisions with specialised function, and in the case of the Ship Department, set up on 1 October, two main features of the new organisation are that responsibility for the construction of HM ships will be concentrated in a single division (Naval Construction Division) and the design staff engaged on the same or related projects will be located close together. This staff will be organised into Ship Groups dealing with various classes of ships. The Admiralty state that the new arrangements for the co-ordination and direction of work at Director General level will enable the Controller to concentrate on matters of general policy.

Reorganisation of the material departments has been necessitated by the need for a high degree of co-ordination at the highest level. At the same time, the Admiralty point out that in one sense this represents a return to the organisation in effect in the last century. Until 1887 there was only one headquarters department responsible for the design and construction of HM ships and their equipment with responsibilities even wider than those now given to the Director General Ships.

Electricity and the Consumer

The Central Electricity Generating Board's reduction in the " running charge " of their bulk supply tariff became effective on 1 October. This was made possible by more efficient working of plant during the past financial year, and amounts to a reduction of 0·01*d* per unit from the old charge of between 0·47*d* to 0·46*d*. The fixed charge remains at £6 per kilowatt of maximum demand. The effect of this on consumers will vary from area to area, since the Area Boards are autonomous and have had varying financial experience during the past year. Five boards (South Eastern Midlands, Southern, Merseyside

and North Wales, and East Midlands) recorded losses. Three boards have announced that the reduction in running charge will be passed on to consumers, and the most probable effect will be that in some areas there will be slight reductions in off-peak rates, and some rebates to large industrial consumers. The object of this, as expressed by the Eastern Electricity Board is to pass on the reduction in costs to those consumers whose use of electricity is contributing most to the efficiency of the system—a belated recognition of the role played by industry in subsidising other users. Rebates will be allowed to industrial consumers with higher load factors, and better off-peak rates will encourage higher load factors in other uses. The achievement of higher load factors is of increasing importance in view of the high capital cost of atomic power stations.

These announcements coincide with the publication of a survey (*A Sample Survey of Commercial Consumers*, The Electricity Council. August 1958)—the first of its kind—of the class of miscellaneous consumers known as "commercial." The results apply "approximately and on the average" to 1953, and are based on a sample of some 5,000 consumers out of an estimated total of 1·3 million in this category. Detailed knowledge of the division of electricity consumption by use is very necessary for accurate forward planning, and surveys of this kind, though necessarily approximate, are extremely useful. The survey reveals the wide range of variation in size of consumer, the majority being concentrated at the lower end; half the consumers accounted for only 7 per cent of the total consumption.

The Council recommend that similar surveys should be made regularly to provide an indication of trends, and it is to be hoped that this will be done and the results compiled and published less than five years in arrears.

Lehrbriefe

An interesting educational enterprise has recently been started by the German refrigeration industry. This industry has been growing rapidly, and has found it hard to recruit suitably trained personnel. In order therefore to improve the technical knowledge of its present employees, it has organised the periodical publication of "*Lehrbriefe*" or instructional letters. The series, Lehbriefe für Kältetechnik, has been compiled by H. Weimar, and is published by C. F. Müller Buchdruckerie und Verlag GmbH, Lammstrasse 2-4, Karlsruhe, Germany (price DM 7·70).

The leaflets, which are designed for fitters and operating personnel, form a series; when this is completed, it will comprise a handbook covering the more scientific aspects of refrigerating plant. The leaflets fall into four groups: technical calculation, physics, refrigeration technology, and electrical technology. They begin with the rules of arithmetic, and carry on to such more advanced subjects as the thermodynamic properties of refrigerants.

Without knowing the needs and organisation of the German industry, or the technical abilities of the men it employs, it is hard to judge whether the content of the leaflets is correctly chosen or adequately explained. Perhaps the most important thing to be noted is that the refrigeration firms in Germany value scientific knowledge sufficiently highly to make a considerable effort to spread it among their staff.

Go Careful With Computers

The rate of development of computer application has been markedly different in the United States from that in Britain. For example, by September of last year, International Business Machines had installed over 700 of their IBM 650 computers in the United States and a further 150 were either installed or on order in Europe.

While an exact breakdown is hard to come by, it is certain that a very considerable proportion of the total in the United States consists of business applications. A recent estimate of the total number of computer systems installed for business applications in the United Kingdom puts the figure as no higher than 76. Of these, more than half consist of British Tabulating Machine and Powers-Samas installations which sell at between one quarter and one half the price of the IBM 650 and are correspondingly less complex machines. This is of course only half the picture; Ferranti for example, with one "commercial" Pegasus in operation, have sold many more for scientific and engineering purposes.

British business may be accused of being overcautious in this. The fact remains that, according to the outspoken Mr. John Diebold, many data processing systems were installed in the United States at least partly for "prestige" reasons, with no very clear idea of how they were to pay for themselves, and with less idea of the scale of reorganisation necessary to make them as useful as they potentially are. His stock answer as to the cost of a business computer—"more than you think"—stems from the experience of many companies.

In Europe, prestige is insufficient, and few if any companies would consider installing a computer on other than sound economic ground. In addition, salaries in Europe are not so high in relation to machine costs as in the United States. This last point is however less significant than it appears at first sight. One of the major reasons for the failure of installations to pay their way is the high cost of staff involved in programming and reorganisation over the lengthy period of time necessary. This is more severe where salaries are relatively high than in the United Kingdom.

From the overall point of view, while it is understandable that companies should wait and see how others fare with the machines, knowledge can only be built from experience. The manufacturers themselves can only convince potential buyers of the value of their products, and can only build up their own experience, by applying themselves to concrete problems.

Collaborative Experiment

For three years Brunel College of Technology has been running a production management course, mainly for graduate trainees who intend to follow a management career in production. Last year an experiment was made of collaboration in the course between the college and two companies: the Glacier Metal Company Limited and T. Wall and Sons (Ice Cream) Limited. The firms co-operated by providing 30 hours each of teaching in the firm or at the college and this was planned jointly by the personnel managers in the companies and the course tutor in the college.

The object of this collaboration is to help the student to relate what he learns on the course to his experience at work and also to give him some idea both of the differences and the similarities between firms. Another advantage was the demonstration to the students of the respect felt by the firms for the college, which helped to reduce their feeling that in the college they were in a world secluded from that in which they were earning their living.

Apart from the normal class instruction and visiting speakers from a variety of organisations, the students were addressed on their special subjects by the heads of departments of the two firms and were also able to have discussions with the chairman and managing director of each company. Because only one of the students was an employee of either of the two firms, they were able to study the firms objectively.

The college has now published a report of the experiment. It is clear, however, that if such a useful method of teaching is to receive more widespread support, some form of incentive for firms and for officials to participate may have to be provided.

An Open Letter

To everyone who appreciates the key role which education plays in our national life.

GENTLEMEN, You may have seen the report in a national newspaper that Mr. Geoffrey Lloyd, Minister of Education, has worked out a scheme which would make it possible for children to stay at school up to the age of 18, whatever type of school they attend. It is designed primarily for children at secondary modern schools, who normally leave at 15. The scheme would be optional—each case being decided by the parents—but it would mean that children at secondary modern schools would feel that they were getting the same advantages as those at the grammar schools, who already have a later leaving age.

Such a scheme, if it were implemented, would be deplorable. To assess it we must compare it with what other countries are planning to do in the educational field, and especially what the USSR is planning to do. I am not suggesting that we should copy other countries, but the inescapable fact is that no country to-day can afford to go it alone, in education or trade or defence or any other activity which impinges on international relationships. Only a few weeks ago Mr. Khrushchev put forward a new plan to ensure that every boy and girl, after seven or eight years at school, goes into industry or agriculture for two or more years. During that period, he must show, by applying himself to part-time study, whether he deserves to enter a university.

The Russian proposal is likely to give certain immediate practical advantages. For example, the number of teachers required in day schools will be reduced because of the shorter normal period of schooling. At the same time, the number of productive man-hours at the disposal of Russian industry will be increased, and there will be no wastage of educational facilities on boys and girls who would, in any case, fail to make good use of their education in later life. But the most important advantage, without doubt, is that the separation of the sheep from the goats will take place at a more reasonable stage in the life of the individual. At the same time, in this country and most other countries far too many people have been given a bad start in life because their schoolmasters and their school reports have made it only too clear to them in their tender years that they were not cut out for the higher posts. A genius may thrive on a bad school report: he may spend the rest of his life proving that the schoolmasters were wrong, to his own benefit and the benefit of the community generally. But there are not many folk of that kind around in any country; for most people, discouragement early in life lasts for the rest of their working days. That is why I consider Mr. Khrushchev's proposals to be highly significant. Doubtless there are snags in the Russian scheme, but at least it seems to be based on a carefully thought-out plan. Can we be assured that our own Ministry of Education are equally clear about their ends and means?

THE EDITOR

Letters to the Editor

WHAT IS AN ENGINEER?

SIR, In his letter "Questions of Definition," published on page 428 of your issue of to-day's date, Mr. S. H. Rendell wonders how many engineers can define electricity, magnetism, plasma and a metal.

Perhaps Mr. Rendell will just tell us "What is an engineer?"

Yours faithfully,
F. H. SMITH,
Librarian.

The Royal Aeronautical Society,
4 Hamilton Place, London, W.1.
3 October, 1958.

STRAIN HARDENING OF CYLINDERS

SIR, It is much to be regretted that Dr. B. Crossland should persist in emphasising the difference in view-point between us (ENGRG., 3 Oct., '58, p. 428). I can only reiterate that, though perfectly well aware of the mechanism of deformation in the early stages and its practical importance to engineers, I deliberately refrained from introducing this complication into my paper. My principal aim was to show how the maximum pressure can be calculated from a knowledge of the strain-hardening properties of the material, and to dispel any illusion that it is directly related to the ordinary tensile strength.

Strain hardening is, of course, a function of work irrespective of the definition of strain, and it is a little difficult to understand why Dr. Crossland should harp upon the point. The progressive yield stress of a metal (i.e., S in equations 1 and 2 of my paper) is, in fact, synonymous with the rate of input of work per unit volume W, with respect of logarithmic strain η. If P, L and A are respectively the current load, length and sectional area of the specimen, while V is its (constant) volume, then, by definition,

$$dW = \frac{PdL}{V} = \frac{P}{A} \cdot \frac{dL}{L} = Sd\eta$$

Though the definition of dW in the first part of this equation is perfectly general, the advantages to be gained by using logarithmic strain in the later parts is obvious. It becomes apparent, for instance, that the total work per unit volume can be obtained by integrating equation 1, or, in broader terms, equation 2 of my paper, "Influence of Strain Hardening on the Dilation of Cylinders under Internal Pressure" (ENGRG., 13 June, '58, p. 756). The chief principal shear stress and chief principal (logarithmic) shear strain can be used for the purpose if desired, since these can be derived from the corresponding direct stresses and strains by means of numerical factors appropriate to the mode of deformation. The facility with which relationships such as these can be manipulated has been largely responsible for the almost universal adoption of logarithmic strains in connection with the theories of plastic deformation, and in accepting them I reap the benefit of the present-day trend.

Yours faithfully,
E. VOCE.

Copper Development Association,
55 South Audley Street,
London, W.1.
3 October, 1958.

Obituary

C. J. INGLIS

Librarian of the Civils

The death occured, at Reigate, Surrey, on 29 September, of Cyril James Inglis, formerly librarian of the Institution of Civil Engineers. He was 66 years of age and had but recently retired from a position he had held for about 35 years.

After the First World War, Inglis rejoined the Civils staff as the assistant librarian and, owing to the untimely death of the then librarian—Parker—he succeeded to the librarianship in an unexpectedly short time. It is to his credit that he should have been considered competent to fill the post in the estimation of the secretary of the time—Tudsbery—and though he had no academic qualification he maintained the library's reputation for resources and service throughout the long term of his office. Inglis had a most remarkable memory, both for faces (and the names that went with them) and for references, at which he may have had only a glance, and this facility made him a popular librarian—particularly with the older members.

It was no small feat, of course, to provide members, armed perhaps with only the most meagre facts, with the detailed references of which they were in need, even although he had around 100,000 volumes at hand.

He leaves a widow and a daughter to whom our sympathy is extended. His son was killed during the last war.

Plant and Equipment

PNEUMATIC SIZE CONTROL

An addition to the range of air gauges made by Teddington Industrial Equipment Limited, Sunbury-on-Thames, is illustrated herewith. The control mechanism houses the pneumatic and electrical components for size measurement, and two or four relays which can be used to control various machine cycles. It is used in conjunction with several different types of gauging head on the machine. Amplification is adjustable, and may be used for any full scale range from 0·001 to 0·004 in. For special applications lower amplifications are available. The pneumatic/electric relays in the control unit are of a new design, and are so sensitive that when used with the highest amplification (5,000), they will operate on a size change of less than 0·000005 in. Signal lights operate in conjunction with the relays. Electric current of 230/250 V, 50 cycles, or, alternatively, 110/115 V, 50 cycles, is required. The compressed air supply should be clean and dry and within the range 50 to 150 lb per sq. in; it need not be regulated.

Three standard types of gauging head are available. For external grinding between centres a caliper gauge is used. It is adjustable for a range of workpiece sizes, and, by using interchangeable jaws, a size range of ½ in to 6 in diameter can be covered. Through feed centreless grinding is dealt with by a gauge head arranged to check the pieces as they leave the work rest. Where the parts leave the machine in a continuous stream an adjustable trend gauging head is used. Two sizes are available, from ½ in to 1½ in, and from 1½ in to 3 in repectively. Where parts leave the machine at intervals, or where the surfaces of the work are interrupted, timed gauging is used. For this purpose there is a caliper gauging unit, which is adjustable from ½ in to 3 in, and fitted with a lever-operated micro-switch for providing the timing impulse.

A separate air jet can be mounted on the caliper to give a pressure impulse to the control unit when a part is in the gauging position. Special gauging heads can also be supplied to suit individual machines.

The Teddington pneumatic/electric control unit, shown here, can be used with various gauging heads for automatic machine control.

WELDING UNIT

The "Balarc B.I.150" arc welding unit has a range of direct tappings and is designed for maintenance or general shop use.

Specially designed as an auxiliary unit, for maintenance and general workshop use, the "Balarc B.I.150" arc welding set measures 11 in by 11 in by 10½ in and weighs 80 lb. It is made by the Ashton-Young Engineering Development Company Limited, 76 Cambridge Road, Kingston-on-Thames, Surrey.

A cast alloy container with an integral lifting handle, houses the transformer, which has direct tappings from 25 to 150A, and will operate electrodes from 16 to 18 s.w.g. The welding set will operate on 200/250 V single phase or 440 V three phase current.

Continuing **Plant and Equipment**

DOSE INJECTOR

A device has been developed by Houseman and Thompson Limited, D. M. House, Jesmond Road, Newcastle upon Tyne 2, for the injection of exact doses of water treatment fluid to feed lines of boilers and economisers. It can be used with any type of slow-speed double-acting feed pump. The injector is shown in the accompanying illustration.

The injector consists in principle of a ram operated by a piston; one side of the latter is connected to the top of the feed pump chamber and the other side to the bottom. The change of pressure that occurs on the reversal of the feed pump drives the injector piston from one end of its stroke to the other and so either draws a charge of treatment fluid into the cylinder or injects it into the feed line. Thus one injection occurs for each double stroke of the feed pump. The stroke of the injector ram, and therefore the amount of fluid injected, can be adjusted by a knurled cap on the unit; on the smaller model each turn represents 0·5 cc and on the larger 2·8 cc. The setting is chosen to suit the site conditions, and depends on the concentration of the fluid used and the amount and content of the feed water. The setting can be based on the flow rate or on the evaporation per day the former being more suitable for fluctuating loads.

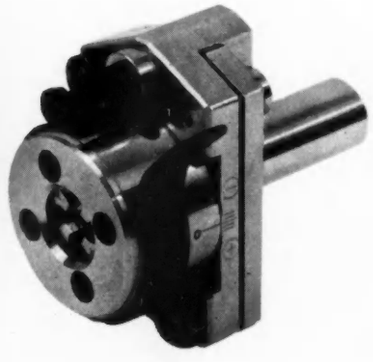
Feed treatment dosing can be carried out accurately with this injector.

SELF-OPENING DIEHEAD

The "XT" Coventry diehead has been designed by Alfred Herbert Limited, P.O. Box 30, Edgwick Works, Coventry, for use on single-spindle automatics. In addition to features common to earlier models it is also equipped with external tripping mechanism to eliminate the possibility of the diehead's opening due to centrifugal force produced by the very rapid indexing of the turret on the high-speed machines.

A particular advantage is its ability to cut short threads; the diehead can be set to trip almost immediately the dies commence cutting. It is fitted with a spring-cushioned shank which allows lateral movement in both directions to compensate for the slight difference which may exist between the pitch of the thread and the forward motion provided by the feed cam. This cushion-action ensures a good start to the thread and also, with the substantial sliding dogs, provides an easy sliding movement ensuring long die life. The spring pressure can be varied.

The Coventry $\frac{1}{4}$ in XT diehead will cut threads from 12 BA to $1\frac{1}{4}$ in Whitworth with appropriate dies, and as the shank is hollow, screws of any length can be cut. Standard Coventry dies are used.



Short threads can be easily produced: the diehead can be set to trip almost immediately after the dies start cutting.

INTEGRAL SODIUM LAMP

A new Osram integral sodium lamp rated at 280 W will be marketed from 1 October by the General Electric Company Limited, Kingsway, London, W.C.2. The new lamp, which has a light output of 16,800 lumens—comparable with that of the 400 W mercury lamp—provides 85 per cent more light than does the 140 W sodium lamp with a separate jacket.

The integral jacket has the same dimensions as the present Osram 140 W integral lamp and houses two arc tubes, each rated at 140 W. The new lamp has an efficiency of 60 lm per W throughout an average life of 4,000 hours. Connections are brought out to a 4-pin cap and each arc tube is operated independently from standard 140 W control gear.

It is suitable for introducing into existing installations in which columns are spaced at distances greater than the normal 120 ft. In such instances it may be advantageous to mount the lanterns at a height of about 30 ft to reduce glare and provide more even illumination.

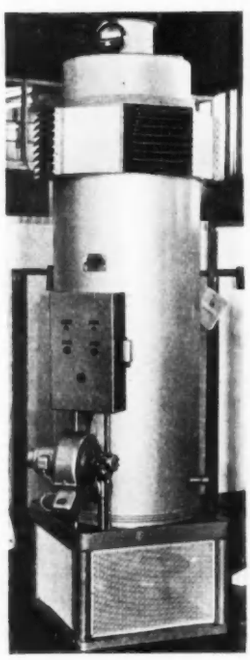
384 KVA ALTERNATOR

The Westinghouse Electric Corporation of America announce that they have received a contract to build a 384 kVA alternator for the Arkansas Power and Light Company, and its driving turbine. The set is to be of the tandem-compound type, that is, the turbine components are arranged on a single shaft and drive a single generator. It is stated that the complete generator will weigh about 519 tons and will be hydrogen cooled—the gas flowing through hollow conductors.

SPACE HEATING

The Beacon oil-fired air heater, made by John Thompson Beacon Windows Limited, Wolverhampton, is a fully-automatic, self-contained unit, with a heat output of 595,000 B.t.u./hr, and a warm air displacement of 320,000 cu. ft/hr, the air leaving the louvred outlets at the top of the heater at a velocity of 15 ft/sec. Using fuel oil at viscosities up to 40 sec Redwood No. 1, the heater gives a temperature difference of 122° F between the suction openings and the outlet louvres. A spiral tube bundle is used as the heat exchanger, and the construction gives a thermal efficiency of 87 per cent.

Maximum fuel consumption is $3\frac{3}{4}$ gallons/hr, and fully-automatic control of the burner ensures economy of operation based on heat requirements and outside temperatures. To prevent discharge of cold air when the heater is started, an adjustable time delay allows the circulating fan to start only when sufficient internal heat has been generated. An electronic flame failure shut-down is provided, and a thermostat protects the heater by shutting off the burner if the circulating fan should fail. Electric power requirements are small; the fan motor is 2 h.p. and the burner motor is $\frac{1}{6}$ h.p.



High thermal efficiency and fully-automatic control are featured on the John Thompson Beacon oil-fired air heater.

Continuing **Plant and Equipment**

COMMERCIAL MOTOR SHOW

At the present time transport is playing an ever increasing part in the fight against rising costs. With the spread of industry the question of moving goods from place to place looms ever larger to the producer, whether he makes large or small goods. It is natural, therefore, that the Commercial Motor Show should draw folk from all branches of industry, and that the fact that motorways are at last actually under construction should add to the interest. The exhibits were a contrast in form—some being extremely specialised but others being definitely of the "all purpose" brand. Public service vehicles formed virtually a class on their own, ranging as they did from the 78 seater double decker Atlantean to the new group of 12 seaters that have been introduced following the change in the regulations. In this article a few of the many items of interest on show at Earl's Court are described.

The 19th International Commercial Motor Transport Exhibition (it is held in alternate years) was opened at Earl's Court, London, on 26 September, by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation. It was a show notable for the number of new models introduced, not merely new since the 1956 show but announced during the last few months. There are, in fact, over 50 of them. Notable too is the rapid spread of air suspension equipment, not only to trailers, but also to goods and public service vehicles. Since it has been estimated that as much as 5 per cent of maintenance costs are spent on attention to springs, air suspension represents a real saving to operators as well as giving an improved ride.

Other very noticeable trends are towards greater driver comfort; indeed, there has been some comment that this has gone almost too far with the provision of cigar lighters and electric shaver sockets. Still, driver comfort is an important aspect, if only from the view of reducing fatigue and accidents. To obtain better turn round times for delivery vehicles, there have been changes in design to give easier loading and unloading; there is a report of one model in which the floor can be adjusted for height to suit the loading dock—a reversal of the adjustable loading dock to suit the lorry. For ease on long journeys the introduction of automatic and semi-automatic gear changing is a big step.

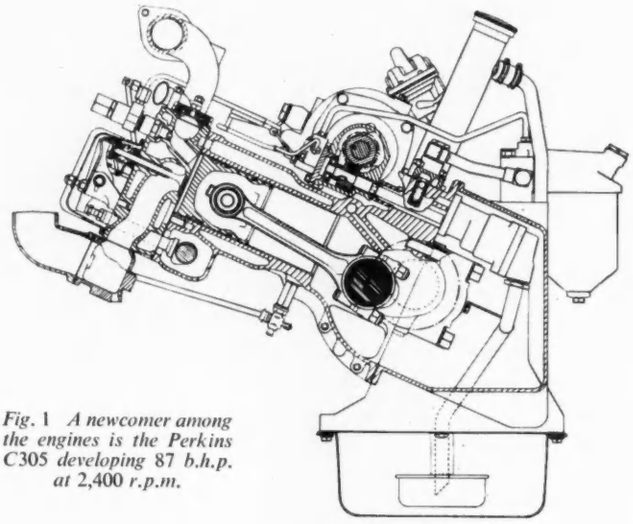


Fig. 1 A newcomer among the engines is the Perkins C305 developing 87 b.h.p. at 2,400 r.p.m.

In general, engines have been increased in size, and top speeds have also been increased, both signs of the new thinking called for by the start on the construction of motorways in this country. Consequently, the differences between vehicles for home and export are becoming less, for, as restrictions are being relaxed in this country, they are being tightened in some others. One prompt result of a change in regulations is the appearance of several 12 seater vehicles for country services.

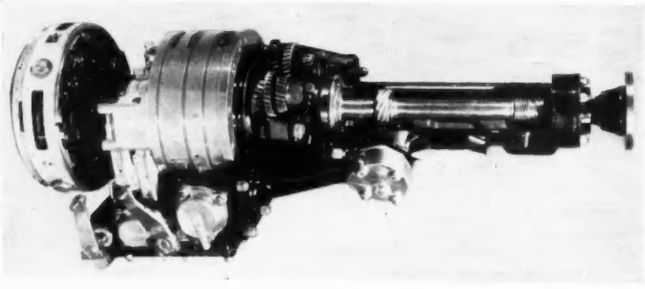
In opening the show, Mr. Watkinson drew attention to the way in which the motorway schemes were progressing. Over 195 miles of motorway were actually under construction and so far the work was up to time. Another 850 miles were being planned (the draft order for the Ross Spur-Birmingham link was announced on the same day) and it was the Government's intention to press ahead with the work. He considered that it was his task as Minister of Transport to give the commercial vehicle industry room to breathe and he intended to do so. He did not, however, say anything about removing purchase tax.

ENGINES

One of the several new engines at the show was the Gardner 6LX described in ENGINEERING some weeks ago. It was displayed both on its own and as fitted to a number of vehicles. The engine develops 150 h.p. at 1,700 r.p.m. with a maximum torque of 485 lb-ft at approximately 1,000 r.p.m. This was the first show for three new Perkins engines. The "Four 99", announced sometime earlier this year, which is rated for 43 h.p. and is being fitted to taxis, cars and delivery vans; the F340, rated for 110 b.h.p. and used in American-built long-wheelbase Ford trucks; and the C305 not previously announced but which is an underfloor engine and is being fitted to the new forward control Commer 4 ton truck and to the Karrier Gamecock. The C305, which is illustrated in Fig. 1, is a six cylinder engine rated at 87 h.p. at 2,400 r.p.m. and developing a maximum torque of 216 lb-ft at 1,300 r.p.m. Bore and stroke are 3·6 in and 5 in respectively, giving a capacity of 5 litres. The cylinder block and crankcase are an integral casting in high duty iron fitted with thin-wall chromium-plated steel liners. The cylinder head is also in cast iron. As in the "Four 99," the spherical combustion chambers are formed half in the head and half in detachable caps. The camshaft is cast iron with chilled cams and is lubricated by an oil bath filled with oil from the rocker gear and kept up to level by a weir. The valves, one inlet and one exhaust per cylinder, are operated by tappets and rockers with clearance adjustment.

Fig. 2 The Austin taxi is a streamline model with diesel engine and automatic transmission.

Fig. 3 The Hobbs Mechaumatic mechanical transmission in its latest form.



The crankshaft is of chromium molybdenum steel running in seven thin-wall main bearings. At the rear is an oil thrower and a scroll seal. Provision is made for turning over the engine by hand. The connecting rods have thin-wall copper lead bearings and the little ends have lead bronze bushes. High silicon aluminium alloy pistons are used. Camshaft and fuel pump, which latter is of the distributor type, are chain driven from the crankshaft and the sprocket on the camshaft can be rotated by increments of $1\frac{1}{2}^{\circ}$ to give timing adjustment. Pressure lubrication is

Fig. 4 For handling either bulk, loose or bagged material there is the Bonallack combined pressure tanker and tipper.

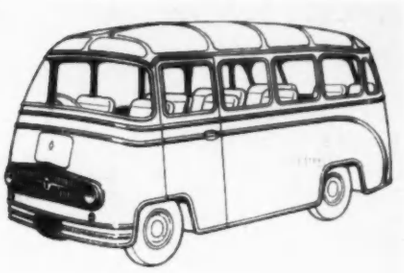
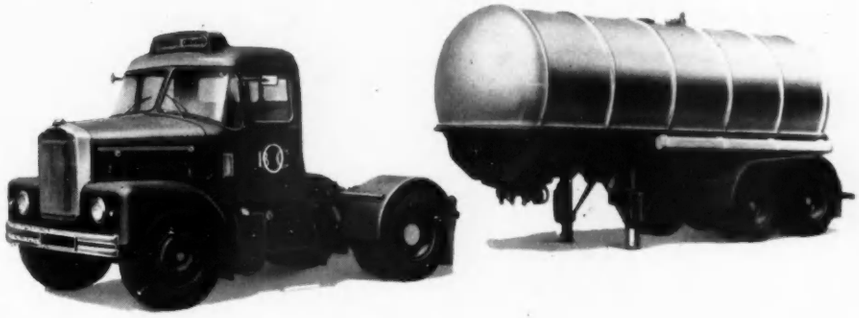


Fig. 5 One of several 12 seaters is the Trojan.

Fig. 6 Another special purpose vehicle is the Scammell 24 ton tanker for liquid oxygen.



provided by a lobe type oil pump driven by skew gears from the auxiliary drive. A 12 volt Thermostart heater is fitted into the induction manifold bend to aid cold starting.

TRANSMISSIONS

As already noted, there has been a big growth in the use of automatic and semi-automatic transmissions. One example is the new Austin FX4 Metropolitan taxi, shown by Carbodies Limited (Fig. 2). In appearance it is greatly different from the traditional London taxi as the open side has gone, replaced by a normal door. Although longer, wider and lower than present models, the FX4 is claimed to be equally manoeuvrable. It is driven by the BMC 2·2 litre diesel engine and has Borg Warner fully automatic transmission. Already 2,000 have been ordered for London.

The Hobbs Mecha-matic transmission is a mechanical system which requires a space only equal to that for a conventional synchromesh gearbox. It is illustrated in Fig. 3. One of its special claims is that it can be used with engines of any power. The action depends on a hydraulic pump driven by the clutch unit which delivers oil at pressures varying with the engine and road speeds. A centrifugally controlled valve admits the oil to the friction clutch mechanism and to the brake elements of the epicyclic gears. When it is desired to drive under hand control, the transmission can be cut out by a switch on the steering column. A Kickdown valve varies the speeds at which the ratios are changed. This comes into action when the accelerator is pressed below the normal full throttle position.

Self Changing Gears transmissions are being used on the Scammell Constructor, and other types on some of the public-service vehicles.

VEHICLE BODIES

A multi-purpose vehicle for bulk transport exhibited by Bonallack and Sons is an example of modern developments. Basically a tipper, it has a removable pressure container that can be used for carrying such materials as cement, which require keeping dry or which are discharged by compressed air. The two components are clearly shown in Fig. 4. The bulk container is held in position by truncated pyramids which fit into corresponding holes in the floor of the tipper or platform body. They are secured by quick-release pins and take up all lateral or longitudinal movements. The sockets in the floor are sealed by traps when the vehicle is operating without the container.

In the container are two overhead manholes for loading and at the rear are the discharge aperture and mixing chamber. On the side is mounted a Wellworthy blower which feeds air to a slide inside the vessel to fluidise the cement or whatever powder is being carried. As the load is discharged the angle of tip can be increased to keep the cement moving to the rear. The capacity of the container is 8 tons of cement, all of which can be discharged to a height of 60 ft in 20 minutes. The maximum air pressure used is 10 lb per sq. in. The containers can be of either light alloy or mild steel and can be removed in a matter of moments when it is desired to use the vehicle as a normal lorry.

One example of the 12 seater public service vehicle was the Martin Walter conversion of the Bedford light van. The Utilabus complies with the "Conditions of Fitness" Regulations and is designed for loads up to 15 cwt. It has a raised translucent reinforced Fibreglass roof and it is fitted with longitudinal bench seats at the rear, seating five a side. Two extractor fans are fitted in the roof. There are entrance steps at the rear and at the side, interior lighting, and room for parcels beneath the rear seats.

Other examples are the conversions of the Austin Omnicoach and the Morris Minibus. In these the side entrance has been retained and automatic steps have been fitted which fold down as the door is opened. The rear door is marked for an emergency exit. There is accommodation for 11 passengers and space for luggage is made by removing the seat beside the driver. The brake and steering clevis pins have been replaced by nuts, bolts and split pins and the exhaust has been directed to the offside.

For rough usage, as for carrying workers on contractors' sites, there is another 12 seater, the Martin Walter conversion of the Ford Thames 15 cwt van, which is similar to the earlier conversions of the Bedford and Austin, by the same firm.

The Trojan 12 seater, built on a new forward control chassis, differs from those already mentioned in that the seats are all placed facing forward. Power will be supplied by a Perkins "Four 99" engine, driving through a four-speed box. The same chassis can be used for an ambulance body and it is essentially designed for passenger work. However, at the exhibition it was shown with a goods body to demonstrate the capacity. In this form a Perkins P3 engine would be used. The bus is shown in Fig. 5. The chassis is rated for 1¼ tons on a 9 ft 4 in wheelbase; the track is 5 ft. The van body is of composite construction and has a capacity of 345 cu. ft.

An example of special-purpose vehicles is the 24 ton Scammell Highwayman articulated tanker for the conveyance of liquid oxygen (Fig. 6). Power is provided by an 11 litre diesel engine developing 161 h.p. at 900 r.p.m. There is a separately mounted Scammell six-speed gearbox and the tractor rear axle is of the fully floating type with spiral bevel and epicyclic reductions giving an overall ratio of 9·4 to 1. The container is made of aluminium alloy, welded throughout with all internal welds ground smooth. It is carried on brackets which allow movement during temperature changes (it can amount to 1½ in when being loaded). The capacity is said to be equivalent to 1,900 standard gas cylinders. The liquid oxygen is kept below −297° F by a 9 in layer of insulating powder between the inner and outer walls of the tank. Protection is afforded by a Pop safety valve and by bursting discs in the tank and canopy.

AIR SUSPENSION

As mentioned at the beginning of this article, one of the features of this year's show is the growth in the use of air suspension. Three examples were on the ACV stand, Routemaster, Reliance and Bridgemaster. Other examples that can be named are the Foden KETU tractor shown with an airsprung Dyson trailer, Leyland-MCW Olympic, Maudslay 14 ton Mercury, a Guy single decker, Tasker and Crane trailers, Eagle and Carriemore. In some cases, the air bellows are only used as helpers to the main springs but in others they are the only springing. The new Leyland Atlantean 78 seater rear engined bus, however, relies on conventional semi-elliptic leaf springs. Dunlop Hymatic, Westinghouse and Andre Rubber were all showing details of air suspension systems.

Atomic Review

Fissile and Fertile

FUELS for nuclear reactors—resources of fissile and fertile materials—using plutonium and thorium—economics of recycling and blending—fuel processing and refining. Where items have been taken from Geneva Conference papers references are given.

Fuel Resources

Uranium reserves fall roughly into two broad economic categories: those from which uranium could be recovered and sold profitably at a price of $10·00 per pound of U_3O_8 or less, and the very low-grade uraniferous shale and phosphate deposits from which exploitation for uranium alone would require a price three to six times that amount. Relatively large tonnages of currently marginal or submarginal ores also are found in some of the uranium mining districts. These ores, which may be considered as forming an intermediate economic class, at present do not constitute a major potential source. However, with continuing exploration and development, and improved methods for preliminary concentration, this intermediate class may become much more important. Very high-grade deposits which might provide uranium at 2 or 3 dol a pound are another possible source. Such deposits are not common and are not likely to be a major source of the world's uranium supply for any extended period.

With respect to reserves of the first category, the 1957 estimates by Canada and South Africa indicate that the developed or partially developed reserves in each of these two countries contain approximately 400,000 tons of U_3O_8. Recorded reserves of the United States are now about 220,000 tons. Nearly two years ago, France published reserve figures of 50,000 to 100,000 tons. These estimates, for the four countries, total about 1,100,000 tons of U_3O_8. Taking into consideration the probable conservative nature of these estimates, and including the reserves of Australia, the Belgian Congo, Portugal, and other countries, total reserves in areas presently under development in the non-Communist countries may be nearer 1,500,000 tons of U_3O_8. Ultimate production from these and adjacent areas may reach or exceed 2,000,000 tons. On the basis of present geological data, and the discovery experience of the past ten years, an additional 2,000,000 tons of low-cost uranium should be developed in the new areas within a reasonable period provided an aggressive exploration programme is maintained. (J. C. Johnson, *Resources of Nuclear Fuel for Atomic Power*, P 1921, USA.)

Plutonium Recycling and Replacement

When plutonium is to be used in place of uranium 235 in a reactor system there are two alternative types of fuel cycle which may be considered. These will be called plutonium recycle and enrichment replacement. In the plutonium recycle system it is considered that all the plutonium produced in a reactor is recycled together with uranium which may be enriched, natural, or depleted according to the reactivity requirements of the system. Under these conditions the concentration of higher isotopes increases in the plutonium until an equilibrium condition is reached.... The plutonium recycle system is a convenient concept for reactor calculations because it leads to steady spectrum conditions within the reactor and because the economics of the reactor can be assessed without attaching any specific value to plutonium.

In an economy in which the ratio C_E/C_F for a diffusion plant is low so that enrichment costs are relatively small by comparison with the cost of natural uranium, the plutonium recycle scheme has the advantage for reactors which require only slight enrichment of permitting the discharge from the fuel cycle of heavily depleted uranium, thus reducing the natural uranium feed requirements. (C_E is the cost of producing unit change in separation potential in 1 kg of uranium; C_F is the feed cost.) For a typical European economy where separated fissile material is likely to be at a premium for many years and where there is every prospect of adequate supplies of natural uranium, it is most unlikely that a plutonium recycle scheme would be adopted. This scheme is also unrealistic in that it restricts the availability of plutonium for a particular reactor in the power system to that material which has been produced by the same reactor. In practice it is likely that there would be a net transfer of plutonium between the various reactors which will make up a power system.

In the enrichment replacement scheme, which is more promising, plutonium is used in conjunction with a natural uranium feed to provide fuel of the required enrichment for a particular reactor. (N. L. Franklin *et al*, *Economics of Enrichment and of the Use of Plutonium and Uranium* 233, P54, UK.)

Using Plutonium in Reactors

Plutonium is available as a fully separated fissile material. The separation from the fertile components is achieved chemically and there is no value of C_E which corresponds to that for uranium 235 in a separation cascade. Accordingly, if plutonium is to be used in place of uranium 235 the most valuable application will be that in which it serves in place of material of full enrichment. On the other hand, its use at lower effective enrichments, for example by blending with natural uranium, does not involve a loss of separation value and the plutonium can be recovered chemically at relatively low cost....

Although fast-fission reactors represent the ideal method of burning plutonium (since all its isotopes are fissile to fast neutrons and so to a significant degree is any diluting uranium 238), fast reactors are unlikely to be technically developed before 1970. For the present, therefore, the utilisation of plutonium is likely to be restricted to types of thermal reactor for which design studies or prototype construction are already under way. Within such reactors, using the enrichment replacement system, the plutonium may be introduced as general enrichment or as spikes. In the former case the plutonium is incorporated in the natural uranium and in the latter most of the channels of a reactor contain natural uranium fuel, the remainder being occupied by plutonium free of fertile material. It will not, however, be practicable to employ a fuel element with a high plutonium content since such a fuel is either insufficiently robust or has inadequate heat transfer surface. For this reason, plutonium spikes are likely to consist of a small proportion, perhaps 1 per cent by volume, of fissile material carried in an inert matrix. The matrix material must have a low neutron absorption cross-section and good conductivity, compatibility, and irradiation stability properties.... When plutonium is incorporated in a thermal-reactor fuel it is unlikely to be present to the extent of more than 10 to 20 kg per ton. (P 54)

Economic Consequences of Using Plutonium

The economic consequences of the technical problems of the above systems are insufficiently understood to permit precise comparisons but the main implications appear to be as follow.

(1) With general enrichment the production of new plutonium takes place in all channels. With the spike system the conversion factor in the spike channels is zero and that in the remaining channels is correspondingly increased. To maintain the heat output of the spike channels frequent fuel shuffling and replacement will be necessary. This may be partially compensated if the increased reactivity lifetime of the natural uranium fuel channels can be utilised.

(2) Because recycled plutonium is segregated in the spike system there is a convenient route for discarding plutonium with a high proportion of higher isotopes from the system, should this be desirable. If a burn-up of 70 per cent of the fissile content of the spike could be achieved economically it might be possible to avoid entirely the reprocessing of irradiated spikes.

(3) So long as the proportion of spike channels in the reactor is low most of the fuel for the reactor can be produced with the less exacting health precautions applicable to uranium fabrication. This point would be of particular economic importance when facilities were in existence for fabricating uranium fuel.

(4) It may be possible to select the spike matrix which permits the use of fabrication methods well suited to operation under plutonium containment conditions. On the other hand the spike system calls for two types of fuel for a single reactor and some economics of scale are inevitably forfeit in fuel manufacture and reprocessing.

Present data indicates that for reactors requiring enrichment equivalent to 1·1 to 1·2 C_0 uranium the spike system may have economic advantage but that for higher values general enrichment with plutonium is probably preferable. (P54)

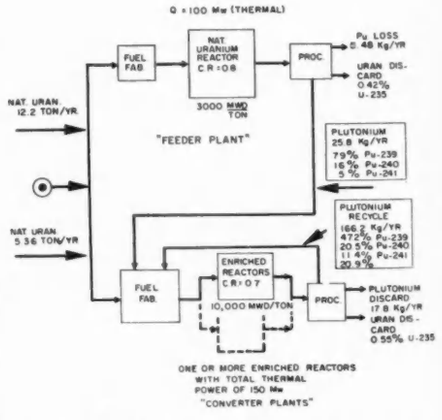
Enrichment and Plutonium Recycling

By analysing the principal characteristics of the basic reactor types it may be shown that a single reactor concept or fuel cycle is unlikely to emerge as significantly superior to all other types. The analysis may be made by considering reactor performance as a function of (1) fuel enrichment over the range of natural uranium to about 4 per cent uranium 235 and (2) the use of plutonium recycle for enriched reactors. . . .

An extension of the plutonium recycle system with immediate prospects for consideration is to combine the fuel cycle of a natural uranium reactor with reactor systems which require enriched fuel for operation. A typical system is shown in the illustration below. Natural uranium is fed to a reactor power plant (feeder reactor) which discharges fuel after approximately 3,000 MWD per ton irradiation. This fuel is processed for the plutonium produced and the depleted uranium is discarded. This plutonium from the feeder reactor plant is fed into the fuel cycle for enriched reactor plants. The enriched reactor plants are fed with natural uranium plus this feeder plutonium and the plutonium recovered from its own spent-fuel processing. Since the enriched reactor plants burn mostly plutonium and convert uranium 238 to plutonium, they are called " plutonium converters." The entire complex is thus called the " plutonium feeder-converter system." (C. Starr, *Fuel Enrichment and Reactor Performance*, P1078, USA.)

Using Uranium 233

The incentive to use the uranium 233 thorium fuel cycle in thermal reactors is provided by the high η value (2·3) of uranium 233 which permits breeding to take place in any reactor of good neutron economy. (η is the average number of neutrons liberated per neutron absorbed in fuel.) Uranium 233 can be produced only by the



Circuit for plutonium feeder-converter system.

irradiation of thorium 232. The production cost will be related directly to the cost of uranium feed and separation effort in a diffusion plant. In practice it is likely that uranium 233 will be at least as expensive as uranium 235 of high enrichment. With typical European figures of C_F and C_E, the production cost for uranium 233 might be £15,000 per kg. It is clearly impossible to use this material as a fuel in the type of gas-cooled reactor at present being constructed in the United Kingdom, since with current efficiencies and fuel ratings the capital cost component for fissile material investment would be £150 to £200 kW installed. Even for the more advanced gas-cooled reactor this investment is not reduced below about £80 per kW installed, and to be competitive when operated on a uranium 233-thorium cycle the reactor must have an average fuel rating of about 1 MW (E) or 3 MW(H) per kg of fissile material.

These figures show that for the types of gas-cooled reactors which could be brought into operation during the next decade, the use of the uranium 233 thorium fuel cycle will not be economic. However there are other ways of producing uranium 233 and other types of reactor in which it can be used. For instance, the uranium 233 could be produced in one type of reactor using a thorium-based fuel enriched with plutonium and used in another type of reactor operating on the uranium 233 thorium fuel cycle which could, in principle, be at least self sustaining in fissile material. (P54)

Re-enrichment Versus Blending

A recent study has considered the relative economics of re-enrichment by recycling enriched uranium fuel through a diffusion plant and by blending, or the addition of highly enriched uranium 235 to the spent fuel. The alternative routes for obtaining uranium oxide (UO_2) of the required enrichment are: (1) the uranyl nitrate may be converted into UF_6 and returned to the Government diffusion plant for re-enrichment; or (2) sufficient fully enriched uranium (about 95 per cent uranium 235) may be purchased from the diffusion plant, converted to UO_2, and blended with the UO_2 obtained directly from the nitrate to produce fuel of the necessary total enrichment. The table below gives the result of the comparison, which applies particularly to the United States. It would appear that at

TABLE.—*Present Cost of 1 kg of 3 per cent Enriched Uranium in Oxide Form*

	Dollars
(1) Recycling (re-enrichment from 2 to 3 per cent uranium 235)	
3 per cent enriched uranium	375·50
2 per cent enriched uranium	220·0
Difference	155·50
Conversion nitrate to UF_6	5·60
Loss during conversion	2·20
Conversion UF_6 to UO_2	23·16
Loss during conversion	3·76
Total	190·22
(2) Blending (blending fully enriched uranium 235 with 2 per cent to obtain 3 per cent)	
10 gm fully enriched uranium	171·00
Conversion, nitrate to oxide	5·60
Loss during conversion	2·20
Conversion, 10 gm UF_6 to UO_2	7·72
Loss during conversion	1·71
Total	188·23

present costs is would be less expensive to blend fully enriched uranium 235 with residual fuel recovered from the separation plant and that the advantage would decrease or shift to recycling as conversion costs are decreased. Taking account of blending and analysing costs might, however, swing even the present-day advantages to recycling. (*Technical Progress Reviews—Power Reactor Technology*, prepared for the USAEC by Dr. W. H. Zinn and associates, GeneralNuclear Engineering Corporation, Dunedin, Florida.)

Pyrometallurgical Reprocessing

Attempts are being made in the United States and elsewhere to find cheaper methods of fuel processing. These, in general, are non-aqueous processes carried out at red to white hot temperatures. Four types of process have received the most attention.

(1) *Melt refining.*—Purification is accomplished by melting the spent fuel in a suitably reactive container. Some of the impurities react with the container and separate in a layer along the container walls. Some of the other impurities evaporate at process temperatures and boil away. Still other impurities are not removed. These are generally beneficial to fuel stability. For the EBR II (Experimental Breeder Reactor-II) spent fuel will be melted in a zirconium oxide crucible. Refining will be carried out at 1,300° C in three to four hours. Under these conditions the volatile fission products distill out of the melt. Those elements forming oxides more stable than oxides of uranium oxidise and separate into a slag layer. The zirconium oxide crucible supplies the oxygen for these reactions and in turn is reduced to a sub-oxide. The less reactive elements, niobium, molybdenum, technetium, ruthenium, rhodium, and palladium, are not removed by the melt refining process.

(2) *Extraction by molten salts or metals.*—If molten uranium-plutonium metal, for example, is mixed together with molten magnesium, the plutonium will leave the uranium and dissolve into the magnesium. Fissile materials, or alternatively, the impurities, may be removed from the molten fuel by this method.

(3) *Fractional crystallisation from low melting point metal solvents.*—Metals in a molten mixture crystallise out at different temperatures as the general temperature of the mixture is lowered. The process consists of dissolving, at a high temperature, spent fuel in a solvent (melted) metal such as zinc. The temperature is then carefully lowered. As this happens, a crystalline compound of uranium and zinc, free from most of the original impurities, will form. These crystals can then be separated from the remaining liquid and its dissolved impurities. To recover the uranium, the crystals are heated, thereby evaporating away the zinc.

(4) *High temperature electrorefining.*—This process resembles electroplating, only a suitable molten salt, instead of a water solution, is used as the electrolyte. Spent reactor fuel is dissolved in the molten salt at one side of a container, and purified metal is deposited at the other side of the container. This is accomplished by an electric current flowing through the system. (M. Levenson and H. Schraidt—Argonne National Laboratory—*Developments in Pyrometallurgical Reprocessing*, P1795, USA.)

Fluidised Bed Process for Uranium Refining

A new and considerably simplified refining process for conversion of uranium ore concentrate into gaseous uranium hexafluoride (UF_6) was shown by the Argonne National Laboratory at the Geneva Conference on atomic energy. An exhibit, prepared by Argonne's Chemical Engineering Division—a 5 ft high, 8 ft long model—which showed schematically the fluidised-bed uranium ore concentrate refining process. The process uses an improved technique, known as fluidisation, for performing chemical conversions. Uranium compounds are made to react with various gases in sequence to produce the uranium hexafluoride, which is then purified by a distillation method. Purification by distillation is much simpler than the method currently used, which requires extraction of uranium salts with organic solvents. The cost of producing UF_6, from which the isotope uranium 235 is separated in the normal way, is expected to be considerably less by the new process than by the older method. Allied Chemical Corporation is soon to install a 5,000 ton per year uranium processing plant at Metropolis, Illinois, which will utilise this process.

Fluidised Bed Process.—First, the blended ore concentrate, which is in fine powder form, is processed into granules of uniform composition and size. The prepared concentrate (U_3O_8) is then fed into the first reactor—the fluid-bed reduction reactor—where the ore concentrate reacts with hydrogen gas and is reduced to uranium dioxide (UO_2), or brown oxide. In the second reactor—the fluid-bed hydrofluorinator—the uranium dioxide reacts with hydrogen fluoride and is converted into uranium tetrafluoride (UF_4), or green salt. Finally, in the third reactor—the florination reactor—the uranium tetrafluoride is fluorinated and converted into uranium hexafluoride. The gaseous UF_6 then goes to a distillation tower for further purification.

Notes and News

Uranium Treatment in Australia

A new Australian process for extracting uranium ores, known as the pulp-in-resin process, is being tested at Rum Jungle in the Northern Territory. Developed by the Industrial Chemistry Division of the Commonwealth Scientific and Industrial Research Organisation, the process involves the passage of a pulp of uranium and other minerals through a bed of special resin. The uranium is subsequently, washed out of the resin. Output of uranium from Rum Jungle is now about 200 tons a year.

Uranium Extraction Plant in Sweden

Plans for a new uranium extraction plant using native schist deposits from Mount Billigen in south-west Sweden are now well advanced according to AB Atomenergi. The new plant to be called the Ranstad Works will produce 120 tons of uranium a year, which means the mining of 900,000 tons of crude schist. The refined ore contains about 300 gm of uranium a ton. The total cost of the works, including crushing and sorting plant and administrative offices will be around £8 million with another £800,000 for the refinery. The Ranstad Works should be completed in 1962.

Gas-Cooled Reactor Invitation

Mr. John A. McCone, chairman of the USAEC, has announced that the Commission is inviting proposals for the development, design, construction and operation within the United States, including its territories and possessions, the Canal Zone and Puerto Rico, of a gas-cooled graphite-moderated nuclear power plant of sufficient size to serve as an effective prototype for a future full-scale power plant of similar design. USAEC designs are for reactors having an electrical output from 30 to 60 MW. The invitation is extended to individual organisations or groups of organisations representing privately, publicly or co-operatively-owned power groups, and to equipment manufacturers or others. Proposals must be received by the Commission within 60 days from 22 September, 1958. Proposals submitted in response to this invitation may incorporate reactor designs and further development considered by the proposers to be appropriate and desirable, provided the proposed reactor be designed to operate with an exit gas temperature of at least 1,000° F and reactor construction be completed not later than 31 December, 1962. The Commission will furnish to potential proposers on request Commission gas-cooled power reactor designs.

Heat Transfer Course

" Heat Transfer in the Nuclear Power Plant " is the subject of an evening course of eight lectures to be given by H. F. J. Hadrill (research and development, CEGB) and R. Vaux (Imperial College) in the Department of Civil and Mechanical Engineering, the Polytechnic, 309 Regent Street, London, W.1. The lectures will be delivered on Tuesday evenings from 6.30 to 8.30 p.m., commencing 14 October, 1958. The fee for the course is £1 1*s* and enrolment forms may be obtained from the head of the department. The course will include typical design calculations.

IAEA Fellowship

More than 100 fellowships for atomic energy studies have been granted by the International Atomic Energy Agency, and these will be taken up by students of various nationalities in the new academic year. Candidates for about 200 more fellowships are being reviewed.

Special Article

ROAD ACCIDENTS

On the Spot Investigations by the Road Research Laboratory

Fig. 1 Broken laminated-glass windscreen; the front-seat passenger was severely cut.

By H. J. H. STARKS, B.SC., PH.D., D.I.C., F.INST.P.*

In 1957, more than 5,500 people were killed, 63,000 seriously injured and 200,000 slightly injured on the roads of Great Britain. These are large numbers, yet a road accident is a comparatively rare event to most people and it is only when we or members of our family or our friends become involved that the consequences of these accidents in terms of human loss and suffering are brought home to us. Many people tend to accept road accidents and injuries as inevitable consequences of our modern way of life.

The number of people travelling by car or motor-cycle has been rising rapidly in the past few years. Since 1950, an extra two million private cars and half a million motor-cycles have been licensed, an increase of about 100 per cent. This may account in part for the increasing number of accidents and for the greater interest being taken in certain aspects of safety; recent American work on vehicle safety measures is also becoming known and the medical profession, both in Great Britain and in the United States, has recently been drawing special attention to the need for improvements in the design of vehicles, particularly to protect the occupants or riders.

This article gives a brief outline of the investigations now being made by the Road Research Laboratory into road accidents with special reference to the nature of the injuries sustained in relation to vehicle design. These investigations mainly comprise on-the-spot studies of accidents occurring within a radius of about eight miles from the Laboratory; they have been made possible by the co-operation of the police and medical authorities in the area concerned. The general scope of the investigations is similar to that of the American work, but there are some important differences in procedure. The first part of the article reviews some American work before detailing some of the findings of the Laboratory.

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ROAD CASUALTIES AND VEHICLES

Nearly 80 per cent of the people killed on the roads in the United States have been the occupants of motor vehicles; practically all the remainder have been pedestrians.

In American discussion of the causes of road accidents, few voices have been raised against the motor vehicle itself. It is hardly too much to say that, until about five years ago, an American who criticised the design of his car from the safety viewpoint would risk being regarded as a rank heretic. This attitude is now changing. As one member of the Boston Automobile Safety Association has said, "Are we to go on assuming that the automobile, as it comes off the assembly lines, is the one perfect thing in an otherwise imperfect world." This changed outlook seems to have stemmed from the foresight and courage of a few individuals, one of them the head of a vehicle manufacturing corporation. The United States investigations are termed "crash-injury" researches. The object is to find the basic facts about injuries to enable the design of cars and their accessories to be improved so as to prevent or reduce the severity of injury to the occupants or other road users in the event of an accident.

The work is being sponsored by the Commission on Accidental Trauma of the Armed Forces Epidemiological Board and by two motor vehicle manufacturing corporations with the assistance of other organisations such as insurance companies. The universities, the police and medical authorities are also playing their part. The researches in progress include:

(*a*) The collection and analysis of data on car accidents and of the injuries sustained in them in sample areas in several States.

(*b*) A study of the forces produced when vehicles are crashed into barriers or into each other, and of the corresponding motion of dummies simulating human occupants carried in the vehicles.

(*c*) The development and testing of protective devices such as safety belts, and of energy-absorbing materials for crash pads.

Details of these investigations have been given elsewhere.[1] The present article is more concerned with the results and their effect on vehicle design. Basically, the results are not unexpected, for the problem is a simple one—at least in a qualitative sense. If a car is suddenly stopped,

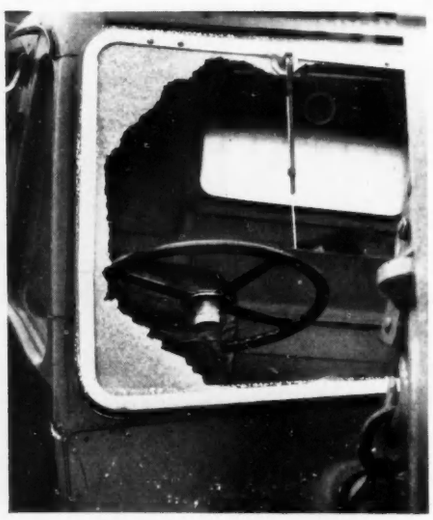

Fig. 2 (left) Lorry involved in head-on collision with car. The driver's head went through the toughened-glass windscreen but he was uninjured.

Fig. 3 (right) Car struck in the rear by a lorry. The seat frame was deformed, and the driver sustained neck injury.

for example by colliding with a fixed object, the occupants continue to travel forward at the speed prevailing just before the impact. They will only be stopped by striking parts of the car or each other, or by being thrown out of the car and striking the road surface. Simple calculation shows that the forces acting on a car that is suddenly arrested may run into many tons, the actual magnitude depending on how quickly the car is stopped; thus, if a car weighing one ton and travelling at 40 m.p.h. is stopped in 1 ft by running into a tree, the force is about 50 tons. An occupant in the same car may, however, be stopped from 40 m.p.h. in much less than 1 ft if, for example, he is thrown bodily against some hard object inside the car, and the force on him may then be many times his own weight. Quantitatively, the problem is a difficult one. We do not know what forces are imposed on a car occupant, nor do we know much about the forces required to produce injury to human beings or damage to vehicles. We would not think of sending a fragile article by post by putting it loose in a rigid container; nor should we expect to escape unscathed without protective padding and restraining devices to prevent our heads and bodies from smashing against the inside of a car if it is involved in an accident. The study of the behaviour of vehicle occupants involved in a crash has been described as a problem in packaging, and the researches now in progress are aimed ultimately at deriving the essential factors necessary for a satisfactory solution of this packaging problem.

Fig. 4 Car struck amidships by another car. The driver sustained concussion, fractured ribs, shoulder and leg injuries.

Fig. 5 Car struck by another vehicle after slewing sideways when braking hard. The driver was seriously injured.

INJURIES SUSTAINED

American data obtained by investigations at the scene of accidents reveal certain definite injury patterns among car occupants,[2, 3, 4]. In head-on collisions, the driver often sustains injuries to the chest or vital internal organs, such as the heart or liver, by being flung on to the steering wheel. The front-seat passenger often receives head or facial injuries by impact with the windscreen, instrument panel or car roof. Back-seat passengers sustain head or body injuries resulting from impact with the car roof or with the back of the front seats. In rear-end collisions neck injuries (whiplash) are inflicted on those in the front seats. In addition other injuries, such as those to the knee (patella) and elbow associated with impact on handbrake levers, glove trays and window-winders, are common. These are the types of injury that might be expected from simple dynamical considerations.

An interesting feature of the American results is the relatively large proportion of car occupants who are injured by being flung out of the car. In most of the accidents occurring on rural roads, the doors of the car opened; when the front doors opened, one out of every three occupants was completely ejected from the car and death or serious injury often resulted. Ejection from the car more than doubled the chance of an occupant sustaining serious injuries.

These on-the-spot studies led to the experiments in which cars are deliberately crashed. The experimental conditions are controlled and equipment installed in the cars or on dummies carried in them is used for recording the forces and motion of the various components. High-speed photographs of the crash are taken and these, in conjunction with the instrumental readings, enable the sequence of events in a collision to be examined. Attempts are being made to relate the results with those observed in accidents on the road; further help is given by experiments with human observers made with the object of finding the physical limits beyond which injury is likely to be sustained. Particular mention may be made of the experiments by Colonel Stapp at the Hollowman Air Force Base in which he has subjected himself to decelerations of up to nearly 50 *g*—corresponding to a stop from 60 m.p.h. in about 2 ft or from 30 m.p.h. in about 6 in, and to the work of Severy, Mathewson and Bechtol[5] at the Universities of California and Yale, in which detailed studies have been made of rear-end collisions and of the mechanism of whiplash injuries of the neck associated with this form of collision.

The American motor-vehicle industry is of course vitally concerned in these matters. Action has already been taken to put into effect some of the major conclusions already reached as a result of the investigations. Improved door locks intended to restrain doors from opening under crash conditions have been produced. Flexible steering wheels with "countersunk" steering-wheel columns are being fitted to some new models of cars, and steering-wheel chest-protector pads are being manufactured for attachment to cars already in use; these are intended to distribute the impact of a driver's body over a much greater area and so reduce the high local forces that otherwise might produce severe local injuries. Padding of the instrument panel of new cars is fairly common and padding strips can be bought by the owners of older cars not so equipped. There is also much interest in safety belts and harnesses and some car manufacturers provide these as standard equipment.

Some of these safety improvements are finding their way into the design of British cars. It does not necessarily follow, however, that what is best for cars of American design is also best for British cars. Apart from differences in the cars, road and traffic conditions in Britain differ greatly from those in the United States. The proportion of different types of accident is different and reflected in the nature of the injuries sustained.

CRASH-INJURY RESEARCH

Up to the present, crash-injury research in Britain has mostly been confined to work on motor cyclists, who not only comprise about one-fifth of all the road fatalities but are mostly young men.

Following the pioneer work of Cairns at the Oxford Head Injuries Hospital on the injuries sustained by the riders of motor-cycles, the Traffic Accident Section of the Army Operational Research Group, at the request of the Army Medical Directorate, made further studies of the injuries to motor-cyclists[6]. The results showed that head injuries account for most of the deaths and 25 per cent of the severe injuries. This work was followed up by the Road Research Laboratory. Investigations have been made into the principles underlying the design of a satisfactory helmet so that advice could be given to manufacturers to enable them to produce more efficient helmets and an improved British Standard specification has recently been drawn up. An increasing number of motor-cycle riders and their pillion passengers are wearing safety helmets and an assessment has shown the value of a safety helmet in reducing the risk of injury by wearing a helmet.[7]

ON-THE-SPOT INVESTIGATIONS

In 1956, with the co-operation of the Buckinghamshire Police in Slough, a pilot investigation was begun by the Laboratory by making on-the-spot investigations of accidents in the Slough area. The scope of this work has now been widened with the co-operation of the Berkshire Police in Windsor and of the Metropolitan Police in the Staines area. About 300 accidents have so far been attended. A team consisting of three or four, including a physicist, an engineer and a photographer, proceeds to the scene of an accident as soon as a report is received from the police. Photographs are taken of the scene of the accident and of the damage to vehicles or other objects concerned; particulars are noted of the road features, evidence of the manoeuvres of vehicles is sought and the damage sustained is closely examined. As far as possible, particulars of the injuries are obtained and attempts made to determine how they arose. Sometimes it is desirable to make tests on the vehicle or its equipment or to measure the characteristics of the road surface. The procedure adopted depends on the nature of the

Continuing **Road Accidents**

accident and this calls for knowledge and judgment on the part of the research team, most of whom have had experience of experimental investigations into vehicle and road-surface characteristics.

Such a wide variety of accidents occur that an analysis of the 300 accidents examined to date is too slender a basis to do more than point out the trends. A detailed examination and assessment of the data obtained is being made but this will take some time. There is little doubt, however, that as the material accumulates and knowledge increases, extremely valuable information will become available not only to the vehicle designer but to the highway engineer and others concerned with road safety.

Most of the general features of the injuries sustained in personal-injury accidents that have been reported in the United States have been observed in the British investigations. For example, drivers are injured by impact on the steering wheel and front-seat passengers get hurt on the windscreen or instrument panel. There are, however, some notable differences. In the United States, as already mentioned, a large proportion of the occupants of cars are ejected through doors which open during the crash. In Britain it seems there is a tendency for car doors to jam and very few cases of ejection have so far, been seen. The main points emerging that have a bearing on vehicle design are:—

(*a*) Some surprising differences have been observed in the injuries sustained by front-seat passengers who have been flung forward on to the windscreen. If the windscreen has been made of laminated glass, the passenger has nearly always sustained cuts or other head injuries (Fig. 1). On impact, laminated glass usually breaks up into a star-shaped pattern of glass splinters held together by the plastic interlayer. The edges of the glass splinters are very sharp and the broken glass does not yield easily to the pressure of a head upon it. If, however, the windscreen is made of toughened glass, which is used in about 90 per cent of British cars, the windscreen breaks up completely into small fairly uniform fragments which do not cut. The broken or shattered glass often remains intact in its frame but offers little resistance to the impact of a head upon it. If the glass has already disintegrated before the head strikes it, there is little danger of injury other than that caused by glass " dust " and several examples have been seen where a driver's head or head and shoulders have been flung through a disintegrated screen (Fig. 2) without injury. If, on the other hand, the toughened-glass windscreen has not shattered before impact of the head, it might be expected that concussion or other head injury would be sustained (toughened glass is about ten times more resistant to fracture by a rounded object, such as a head, than is laminated glass). In practice, however, concussion does not usually seem to occur; in the first 300 accidents attended not one example of a head injury (other than bruising) caused by impact on a toughened-glass windscreen was observed. Several cases have been seen in which the toughened-glass windscreen was ejected from its rubber-mounted frame and found intact on the road. Some of these windscreens were struck by a passenger's head, others were not. Although the possibility of severe head injuries being sustained on toughened glass cannot be ruled out, medical evidence suggests that the force necessary to produce severe head injury is greater than that required to fracture toughened glass. The main disadvantage of toughened glass is that the driver's vision is somewhat obscured when the windscreen disintegrates, which it is liable to do when struck by a stone flung up by another vehicle; it can also disintegrate spontaneously for reasons which are not yet understood.

(*b*) Front seats usually fail in collisions. Most of the cars examined that have been struck in the rear have shown failure of the front seats; the seat frame itself has deformed under the forces imposed upon it (Fig. 3) or the seat fixings have torn away. In either case the driver has usually lost control of the vehicle and passengers in the rear seat have had their legs trapped between their own seat and the back of the front seat. In head-on collisions, passengers in the rear may be flung on to the back of the front seat and thus increase the forces acting on the front-seat occupants.

(*c*) In rear-end collisions, some cases of neck injury sustained by the driver have been reported. These neck injuries sometimes took several days to develop and, though they seldom prove fatal, they are usually slow to heal and sometimes have far-reaching ill effects.

(*d*) Severe facial and dental injuries sustained by rear-seat passengers flung on to the hard back of the front seat have been reported.

(*e*) Several examples have been seen of a car which has been struck amidships by another vehicle (Fig. 4) or which has crashed sideways-on into another vehicle (Fig. 5) or into a fixed object such as a lamp standard. Extensive damage has usually occurred even in minor impacts of this nature, and severe injuries have usually been inflicted upon the occupants. Detailed studies of the deformation of the vehicle structure are likely to indicate possible ways in which the extent of the damage could be reduced by changes in design.

(*f*) In most of the accidents in which side damage was sustained, it seemed likely that loss of control contributed largely to the accident. Loss of control appears to be more frequent than has been suspected hitherto. It can arise by cornering too fast, by the rear wheels locking during emergency braking or when there is front-brake unbalance. The skidding of wheels when braking is a problem offering considerable scope to the vehicle and brake designer in order that a braking system may be produced in which the wheels do not lock. An experimental braking system designed to meet this requirement has recently been demonstrated by the Laboratory, and its further development seems to offer promise in helping to avoid these side impacts which usually have such serious consequences to the vehicle occupants.

(*g*) An interesting series of observations on the damage to steering wheels and steering columns and on the corresponding injuries sustained by the driver has shown that a steering-wheel assembly that is capable of yielding (Fig. 6) is less likely to cause serious injury to the driver than a more rigid type of steering-wheel assembly (Fig. 7). In high-speed impacts, there is a tendency in some cars for the steering column to be driven up into the vehicle like a spear, usually with severe or fatal consequences to the driver (Fig. 8).

(*h*) Several examples have been seen of injuries sustained due to front-seat passengers

Fig. 6 (above) Car involved in head-on collision. The driver sustained a fractured wrist and the front-seat passenger was killed.

Fig. 7 (left) Car ran into rear of commercial vehicle. The car driver sustained fractured ribs and facial cuts.

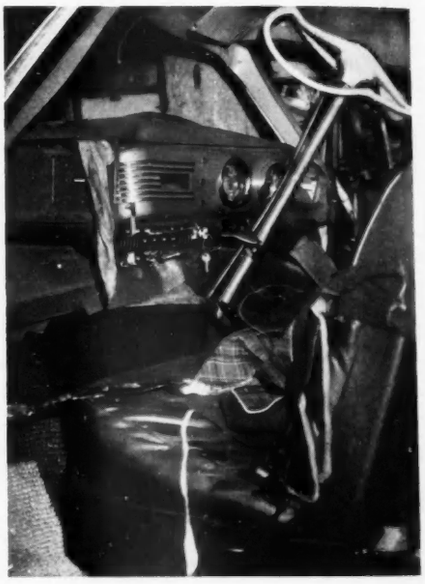

Fig. 8 (right) Car involved in high-speed head-on collision. Driver and front-seat passenger killed (note steering-wheel touching roof).

striking the top of the instrument panel. Padding of this panel is desirable, and in some new cars this is being done. The nature of the padding material, however, is most important if it is to be effective; some of the materials now being used are too soft for the purpose.

SAFETY-BELTS

In most of the cases cited above, the vehicle occupants have been injured by being flung about inside the car. This naturally raises the question of the value of safety belts or a safety harness. If a safety belt is to be effective, it must be properly designed to withstand the forces likely to be imposed upon it and it must be attached to the car frame and not to the car seat.

Objections are of course made about the use of safety belts; the idea of being strapped into a seat seems repugnant to most people—though in aircraft belts are accepted without question. Their use in cars, however, may well be considered worthwhile, especially for children, for they are likely to reduce the chances and the severity of injury.

Tests on safety belts and harness in the United States indicate that a safety harness comprising a lap belt and shoulder or chest straps is more effective than the simple type of lap belt.

Apart from the main points mentioned above, evidence has been collected on the part played in accidents by road features such as kerbs, telegraph poles, lamp standards, and trees. Some of the accidents investigated clearly originated in a vehicle defect, in some cases due to improper maintenance or neglect which could have been detected by a simple check or even casual inspection.

FUTURE WORK

Although these accident investigations are interesting and are producing valuable information on injuries in relation to vehicle design, they lack the quantitative information that is necessary for the detailed design of protective measures. To obtain this quantitative information, experiments are required in which actual vehicles or their components are subjected to impacts of controlled magnitude and measurements made of the deformation and of the forces producing them. The results, taken in conjunction with accident investigations at the roadside, should provide the numerical data that the vehicle designer needs to build increased safety into his cars.

Acknowledgement.—The British work described in this article was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of Road Research.

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Automobile Engineering

THREE OF THE NEW CARS

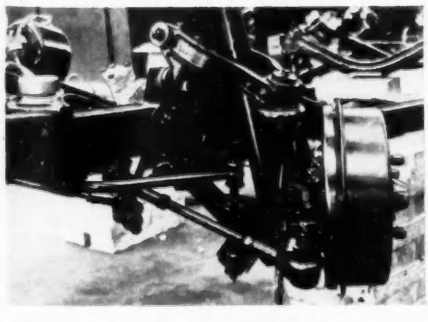
By Gordon Wilkins

ROVER 3-LITRE

Unit Construction Body with Manual or Automatic Transmission

The Rover 3-litre is a new fast touring car additional to the existing range. It has an entirely new 5-6 seater unit-construction body with wrap-round windscreen, big windows and a large trunk. Engine, gearbox, steering and front suspension are mounted on a detachable subframe insulated from the main body by six rubber mountings. The engine is a six-cylinder unit of customary Rover F-head design with seven-bearing crankshaft and gives 115 b.h.p. gross at 4,250 r.p.m. on a compression ratio of 8·75 to 1. Maximum torque is 164 lb-ft at 1,500 r.p.m. Maximum b.m.e.p. 136 lb per sq. in.

The 3-litre Rover has a rubber insulated sub-frame to counteract road noise.



Front suspension is by wishbone and radius arm with a laminated torsion bar.

Transmission is through a manual four-speed box with option of Laycock de Normanville overdrive or the Borg Warner fully automatic. Front suspension is new, using wishbones and laminated torsion bars, and brakes are Girling with two trailing shoes at the front assisted by a servo of the suspended-vacuum type.

The car reflects modern ideas on appearance but it shows Rover's customary rugged individuality in execution. The grille is bolder than before and the usual side lamps in the wings have small red plastics tell-tales. Near them are the amber turn indicators, fussily grouped with a scrip name plate. Airducts at the lower corners of the wrap-round screen, adjustable for flow and direction, de-mist the glass and direct fresh air to the interior. Air is taken in through a die-cast grille at the base of the screen, well away from exhausts of other cars. Over each window is a plastic deflector. Instruments and switches are grouped in front of the driver under a cowl, the whole assembly being finished in matt black to minimise reflections. The steering wheel has a recessed centre and carries a horn ring; below it are triggers to work headlamps, turn-indicators and overdrive (the overdrive can also be cut out by kicking down the accelerator). Manual transmission models have four pedals. There is an organ accelerator pedal on the right and on the opposite side is a foot rest to match. Pressing it works the headlamp dipper. The gear lever is Rover's remote control floor-mounted type.

The engine is developed from the 90 and 105 power units, with bore increased from 73·03 to 77·8 mm and stroke unchanged at 105, giving 2,995 cc. Compression ratio is normally 8·75 to 1 but 7·5 to 1 is available on demand. The crankshaft runs in seven copper lead main bearings. To accommodate the extra bearing the width of the big end bearings has been reduced by about $\frac{1}{8}$ in but Rover designers are satisfied there is still an adequate safety margin. Roller tappets are used, as recently introduced on the Land Rover, and the timing chain has a hydraulic tensioner. The inlet manifold, partly cast into the cylinder head, is water heated and carries a large SU diaphragm-type carburettor. On the opposite side of the engine is the cast six-branch exhaust manifold, feeding into a single exhaust pipe.

The clutch, hydraulically operated and 10 in diameter, is larger than on other models, but the gearbox is unchanged. Rover have abandoned their own automatic transmission and have adopted the Borg Warner as optional alternative on the 3-litre. A control on the facia allows the intermediate gear to be held when required. It is not electric, and acts through a cable on the governor control lever. The propeller shaft is in two sections, with rubber-insulated centre bearing and four grease points. Otherwise regular chassis greasing is eliminated in the usual Rover manner by use of rubber bushes, pre-packed bearings, oil reservoirs sealed for life, or oil reservoirs which only require attention twice a year.

The detachable rubber-insulated sub-frame represents a determined effort to isolate road rumble. The change to laminated torsion bar suspension is also concerned with that problem. It was necessary to raise the front roll centre (now 5½ in above the ground) and also move the lower wishbone pivots from their rather vulnerable position low down in front of the engine. Shorter wishbones were therefore used with pivots placed higher, and the pivot axes were angled to counteract nose diving during hard braking. The upper arm is a conventional wishbone; the lower is a radius arm with diagonal strut behind it. Ball joints form the steering pivots. In cutting down road noise a torsion bar offered better prospects than a coil spring, but a simple torsion bar would have had

Continuing **Automobile Engineering**

to be so long that it would have extended well back under the body. A laminated torsion bar, having shorter length for the same characteristics, was therefore adopted.

The pursuit of silence has also produced an interesting method of mounting the rear half-elliptic springs. The front attachment is a circular Metalastik bush, with the second leaf of the spring wrapped round it as a safety measure. At the rear, the conventional shackle is replaced by a small triangular bracket bolted to the spring leaf, and bonded to two rubber pastilles to combine longitudinal flexibility with lateral control. The springs have eight leaves and a helper leaf for heavy loads. They are wider than those on other models (3 in against 2½) and longer (50 in against 46) and are covered with grease-filled gaiters. A roll understeer effect is obtained by inclination of the springs.

Steering is by Burman recirculating ball system with three-piece track rod. The steering ball joints have sealed lubricant reservoirs and only require inspection at long intervals. The body unit is built by the Pressed Steel Company. Body, doors, bonnet and trunk lid are all steel, unlike other Rovers where aluminium is used for unstressed panels. The reason for the change is largely one of cost. The underside of the body is dipped in paint and sprayed in black, then coated with anti-corrosion sealing compound. The spare wheel is carried in a separate cradle below the trunk and the battery is in one of the rear wings, standing in a glass fibre tray.

Other Rover models are continued with the new grille and bumpers (except the automatic transmission version of the 105). They now have padded instrument panels and a slim chromium moulding at the wastline as on last year's two-colour models.

HUMBER SUPER SNIPE

Luxury Six Seater

The new Humber Super Snipe is a large luxuriously finished car using the same basic structure as the Humber Hawk with a new six-cylinder engine of 2·6 litres. The engine has hemispherical cylinder heads with inclined valves operated through two rocker shafts by short pushrods at diverging angles worked by a single camshaft high in the crankcase. It is a " square" unit with bore and stroke of 82·55 mm giving a swept volume of 2,651 cc and produces both a relatively high power output and a good flat torque curve on a moderate compression ratio of 7·5 : 1. It delivers 112 b.h.p. (SAE) or 105 installed at 5,000 r.p.m. and gross torque does not fall below 138·3 lb-ft from 1,600-2,400 r.p.m.

The crankshaft runs in four bearings, all being white metal thin shell type. A single Stromberg down-draught carburettor is mounted on a water jacketed inlet manifold, the exhaust being on the opposite side. The clutch is hydraulically operated and a new 3-speed gearbox has been developed for this engine with synchromesh on all ratios. Optional extra is a Laycock de Normanville overdrive operating on second and top, giving 5 forward speeds.

Alternative transmission is Borg Warner automatic, with a control on the instrument panel allowing the driver to hold the intermediate gear when driving on hilly or winding roads. Brakes are Girling with twin trailing shoes and automatic adjustment at the front. To compensate for the lack of self-energising effect there is a vacuum servo brought into action by pressure of 2 lb on the pedal.

There are three models, saloon, limousine with glass division, and estate car, all very luxuriously finished. Maximum speed is said to be 92 to 97 m.p.h. according to transmission. Kerb weight is 3,351 lb for the saloon and 3,456 lb for the station wagon.

The cylinder block is a deep casting with full length water jackets round all cylinders, and crankcase walls extending well below the crankshaft. The camshaft is driven by chain with hydraulically loaded tensioner and runs in an oil bath formed by a trough cast in the side of the cylinder block. Oil pump and the ignition distributor (which has centrifugal and vacuum control) are driven by skew gears from the camshaft and an oilway bored across the shaft registers with oilways in the casting twice every revolution, thus providing an intermittent supply of lubricant to the valve rocker shafts. The pistons are flat topped and carry four rings above the gudgeon pins.

The Super Snipe has a new 2·6 litre engine.

Brakes have drums of 11 in diameter at front and rear, total lining area being 168 sq. in. Tyres are 6·70-15 on bolt-on steel disc wheels. The latest Burman recirculating ball steering gear is used and is available with power assistance at extra cost. Dimensions: Wheelbase, 110 in (279·4 cm). Track, front 56·5 in (143·5 cm); rear 55·5 in (141 cm). Length, 184¾ in (469·3 cm). Width, 69½ in (176 cm). Height (sedan), 61 in (155 cm). Ground clearance, 7 in (17·8 cm). Turning circle, 38 ft (11·58 m.). Kerb weight. Sedan, 3,351 lb (1,568 kg).; estate car, 3,456 lb (1,578 kg). Tyres, 6·70-15. Electrical system, 12 volts, 51 Ah. Fuel tank, 12½ Imperial gallons (56·8 litres). Price in England, Sedan, £995 plus tax of £498 17s.

AUSTIN A.40

Italian-Styled Body Combines Saloon and Station Wagon Features

The trend towards a new kind of small car, something between saloon and station wagon, with smart appearance and maximum carrying capacity, receives a big impetus with the introduction of the new Austin A.40. It is the best looking Austin for many years, as might be expected, for the Italian designer Pinin Farina evolved the body style. Crisp uncluttered lines enclose four seats and unusual luggage space, and the rear seat backrest can be folded flat for extra freight space, making it a versatile small family car.

There are no technical novelties in the mechanical design but the car is important for two reasons. It marks a definite break with American styling ideas as reflected in cars like the Austin-built Metropolitan, and commits Austin to a sophisticated European style which will be seen on other models during the coming year.

It also shows greater attention to details of fit, finish and appearance. Lamps, switches, door handles and other fittings have obviously been selected with care to fit into the general design. The projecting rear end of the roof and the shallow bonnet with its turned-under front edge are two points where extra cost and complication have been accepted purely to produce a better looking car.

The A.40 has the same engine, transmission and suspension units as the A.35, so Austin agents throughout the world already carry stocks of spares, but it is longer, lower and wider and has bigger brakes. Running weight, at 1,596 lb without fuel, is a little above that of the four-door A.35 saloon but well below that of the 2-door Morris Minor and the A.35 station wagon. Austin claim a maximum speed around 70 m.p.h. and a fuel consumption of up to 40 m.p.g.

Two big doors, 3 ft wide, hinged at their forward edges, give easy access to the four seats and the long flat roof line gives good head room at the rear. A dropping tail gate below the fixed rear window reveals a luggage locker and a spare wheel enclosed in a plastic cover. Normally there is 11½ cu. ft of luggage space below the waistline but when only the front seats are in use, the plastic-covered fabric parcel shelf below the rear window can be unclipped and the backrest of the rear seat tipped forward, giving a total of 18¼ cu. ft of freight space below the waistline.

The steel unit structure is fully rust-proofed and has stood up without trouble to 2,000 miles of rough pavé track at the MIRA proving ground.

Fresh air is taken through a vent at the base of the windscreen and a heater is optional equipment. The doors have drop windows and swivelling ventilation panels with gutters to exclude rain.

The engine is the BMC A-type 4-cylinder o.h.v. unit of 948 c.c. and on a compression ratio of 8·3 to 1, with Zenith carburettor, it gives 34 h.p. (installed) at 4,750 r.p.m. (or 38·5 h.p. SAE at 5,000 r.p.m.). It has a full flow external oil filter, ignition distributor with centrifugal and vacuum control and pressure cooling with pump, fan and thermostat.

European lines and increased carrying room mark the new Austin A.40.

The clutch, of 6¼ in diameter, is the same as on the A.35 but is hydraulically operated; the gearbox has four speeds with synchronised second, third and top, controlled by a remote-control central lever taken from the Austin-Healey Sprite. Drive is through the usual open propeller shaft to the hypoid rear axle. Front suspension is conventional, using A.35 parts but the track is 2¼ in wider and the wheelbase is 4 in longer.

Front brakes (with two leading shoes) have drums of 8 in diameter and 1½ in wide while rear brakes are 7 in by 1¼ in giving a total lining area of 76·2 sq. in which is an increase of almost 25 per cent over that on the A.35. Overall gear ratios are 16·51, 10·80, 6·43, 4·55 to 1; reverse 21·2 to 1. Tubeless 5·20-13 tyres are fitted. Other dimensions are: wheelbase, 83½ in; track front, 47½ in, rear 47 in; length 144½ in; width, 59⅜ in; height, 56¾ in; turning circle, 35 ft; kerb weight less fuel, 1,596 lb; speed at 1,000 r.p.m. in top 14·26 m.p.h.

Companies in the News

Cable Junction

The first major step in the rationalisation of the electric cable industry was taken last week when Associated Electrical Industries Limited announced that they had conditionally agreed to purchase the whole of the issued capital of W. T. Henley's Telegraph Works Company Limited, and that the cable and other manufacturing resources of the companies would be amalgamated. The new group will account for over 20 per cent of cable production in the United Kingdom. Lord Chandos's comment on the deal, " This is not a take-over bid; it is not a financial or a share deal, but an industrial amalgamation designed to meet the needs of the cable industry," indicates quite clearly that some degree of concentration had become inevitable if the leading units in the industry were to survive the fierce competiton now developing both at home and overseas. Earlier, reference was made to the possibility of a merger between W. T. Henley's and Johnson and Phillips (Weekly Survey, 26 Sep.), but no agreement was reached.

The merger of W. T. Henley's with AEI will not solve all the industrial problems and other steps in the same direction can be expected. Nonetheless, it will enable the extensive cable-making capacity constituted by the Siemens-Edison-Swan group and Henley's to be rationalised. Obviously saving will be in capital expenditure through avoiding duplication of effort in research and development and, of course, in a reduction of the present extreme variety of cables being produced. Special emphasis was placed on the need for this kind of rationalisation in a period of rapid technical change which has placed a considerable strain on the financial resources of individual units.

News recently released by Standard Telephones and Cables that they have obtained a contract for a new submarine telephone cable between England and the Channel Islands shows that there is a great deal of work to be done in that field and in general the demand for electrical and telecommunication cable is expected to increase steadily over the next decade. The main problem the industry is facing concerns the immense capacity built up so rapidly after the war, accompanied, as Lord Chandos pointed out, by a considerable variety in types and designs.

Mergers and New Companies

The emphasis in company amalgamation is currently shifting to the need for greater marketing efficiency and for a well diversified range of products. Several industries—textiles and aircraft in particular—no longer offer an attractive field of investment for the large companies in them who are therefore endeavouring to find new " growth " outlets for their spare cash. The wastage of marketing skills over 20 years of " sellers' market " is leading increasingly to the purchase of specialised sales companies and to extensive re-organisation of existing large companies. This trend can be expected to continue and to gather momentum.

A recent example is the union between Rockwell Engineers Limited and Coventry Gauge and Tool Company. Rockwell are essentially a distributing organisation in the machine-tool field with the knowledge and resources to market the precision machine tools manufactured by Coventry Gauge. Camp Bird have announced the merging of the manufacturing and trading operations of three members of their Hartley Baird Division—H. J. Baldwin and Company, Duratube and Wire, and Hartley Electromotives. A new marketing company is to be formed to serve all three. Aveling-Barford have formed a new Canadian company, Aveling-Barford Canada Limited, to boost their spares and service facilities and to provide a nation-wide distributor network. Likewise, Brook Motors have formed Brook Electric Motors of Canada Limited because " recent developments have shown that more concentrated efforts could yield better results and improve service to existing clients."

Diversification is now a " must " for large companies and sheer size also a consideration. In this connection the merger proposed between Platt Brothers and Company and J. Stone and Company (both currently under the chairmanship of Sir Kenneth Preston) is described as a step which would " cement the close relationships which have existed over many years, so creating the conditions for further expansion and making possible more effective utilisation of resources in the future." Much more on these lines will take place in the next year or so, both nationally and on a world-wide basis.

Motor Component Competition

Several makers of motor vehicle components whose annual reports have been published recently agree over one basic trend: competition is increasing. Mr. Allen L. Stock, chairman of Lodge Plugs, reported that profit margins have been reduced, " more noticeably on automobile sparking plugs." Trading profit for the year was down by £20,000 to £109,000, reflecting " a substantial loss " in respect of the company's American subsidiary. Mr. Stock expressed some anxiety lest the American recession " may have delayed repercussions throughout European and Commonwealth markets."

Clifford Motor Components Limited, who held their meeting earlier this month had very satisfactory results—trading profits were up £60,000 to £635,000—due mainly to the prosperity of the motor industry with which the group are very closely allied. Mr. S. C. Joseph, their chairman, pointed out that increased costs were substantially absorbed and that turnover was therefore " more than maintained " in the face of increased competition. The group continued to benefit from their policy of redeployment and from their capital expenditure programme. Mr. Joseph expressed his confidence that " further benefit " would accrue and told shareholders that several suggestions designed to widen the group's field of activities were being investigated.

Engineering Components Limited issued a half yearly report for the six months ended 30 June. Profits are lower by £11,000 to £190,000. The fall was entirely attributable to lower margins. Considerable increases in the output of motor vehicles led to higher production of initial equipment but the demand for replacement parts " remained fairly constant." Group sales rose by 11 per cent as compared with the corresponding period of 1957, but " costs have tended to rise and, in the extremely competitive conditions ruling to-day, profit margins have narrowed."

Nimonics by Numbers

" Nimonic " is the familiar name which Henry Wiggin have given to a range of nickel-chromium alloys designed to withstand the high temperature and stresses realised especially in modern gas-turbine engines. Development of such alloys has progressed from " Nimonic 75 " to the latest " Nimonic 105 "; the whole series has been evolved from the nickel-chromium alloys employed in heating elements. Creep strength of this latest alloy is such that when stressed to 7 tons per sq. in at 940° C it takes 50 hours before rupture. While being a useful property for the designer and engineer, this high strength makes life very difficult for the primary fabricator who is asked to convert cast ingots and billets into bars, sections and sheet. Needless to say, suitable techniques have been found.

Erection of the Henford Works of Henry Wiggin and Company Limited commenced in 1951, the factory being intended as strategic plant for the Ministry of Supply for production of these high-strength alloys. In 1956 the company purchased the works from the Ministry with the aim of concentrating all Wiggin production there and at the same time of modernising and expanding production facilities. The first of three stages in the scheme is now complete and production is going ahead under 7 acres of building coverage. By 1965 planned activity should have spread over 25 acres out of a total site area of 52 acres.

Hail and Farewell

A number of important retirements and appointments have been announced recently by engineering companies, some concerning people known throughout the industry. C. A. Stephens, director and overseas manager of A. Reyrolle and Company, Limited, retires from executive duties (he remains on the board) after 36 years with the company. He is succeeded by W. G. Martin, his deputy, who has been with the company since 1926. Harry Green, director and chief engineer of Metropolitan-Cammell Carriage and Wagon Company Limited, retired on 30 September, and three new appointments were made, D. J. C. Robertson—already on the board—as general manager, J. L. R. Barnes and C. J. E. Large respectively as chief engineer carriages and wagons and chief engineer railcars. Mr. Barnes was appointed a special director of the company.

A major change takes place at ICI. John Edgar Braham, who has been engineering controller of the group since 1950 (having joined the company in 1928) retired on 30 September. Mr. Braham was also chairman of the ICI Engineering Committee. His successor as engineering controller is Robert Hugh Dibb, who has been engineering director of ICI Plastics since 1946. Coventry Gauge and Tool Company Limited have appointed Leonard Baker as deputy managing director. Mr. Baker came from Hamworthy Engineering, and was before that superintendent engineer of the Holt Line. This follows the departure of Robert Atkinson, who left Hamworthy where he was managing director to take over the same position in William Doxford Engineers.

In the instrument industry, George Kent Limited announce a number of important changes on their board. Commander P. W. Kent relinquishes the post of managing director and remains as chairman, W. A. Hartop becomes managing director and a new director, T. P. W. Norris—lately chief personnel officer of the Vickers group—has been appointed deputy chairman. R. E. Handford, deputy managing director, relinquishes his executive functions after 45 years with the company and remains on the board. Two directors, W. Guy Ardley and Leslie H. Kent have retired.

At Yarrow and Company a son succeeds his father as managing director. Sir Harold Yarrow remains as chairman and Mr. Eric Yarrow takes over the managing directorship. Finally, Wickman Limited announce that Mr. J. Hodkinson has been appointed a director of the company with overall responsibility for the company's machine tools export interests. He will retain his present appointment as managing director of Machine Tools (India) Private Limited (a Wickman associated company) which he assumed upon joining that company in June, 1954. Prior to joining Wickman Limited, Mr. Hodgkinson had held appointments with the Associated British Machine Tool Manufacturers' Indian Company, and Craven Brothers (Manchester) Limited. During the war he was Deputy Director-General (Tools), and Machine Tools Controller with the Government of India.

The Human Element

Top People of To-day

Swift promotion comes to but a few and in industry perhaps less readily than in most other fields. Hard won experience accumulated at each lower rung is still looked upon by most as the necessary qualification for the top of the ladder. Gradually, however, is emerging the feeling that a young man likely to become a top manager should at 30 or so clearly be seen on the way. For the university graduate who may not come into industry until the age of 23 or 24 (National Service still retards entrants by a full two years) this means that the traditional training for management must give way to a new approach. An example of this is provided by the career of Mr. Geoffrey N. Iley, an employee of the Nuffield organisation.

Mr. Iley is just 30 and was, two days before his thirtieth birthday, appointed production manager of Morris Motors Limited, Cars Branch, Cowley. This is one of the biggest production engineering jobs in this country and it is, therefore, interesting to glance at Geoffrey Iley's career and qualifications. He is a B.Sc.(Eng.), a graduate of both the Institution of Mechanical Engineers and the Institution of Production Engineers. (To see the letters G.I.Mech.E. after the name of a senior executive is striking in itself.) His education was at Oakham School, Rutland, and Birmingham Central Technical College. In 1945 he joined Wolseley Motors, then of Birmingham as an apprentice. Two years later he won a Nuffield Scholarship to Birmingham University where he read economics. In 1948, he was transferred to Morris Motors Limited, Cars Branch (planning department) and in 1953 took up an appointment as production engineer with the Staffordshire Steel Construction Company. In 1955 he was appointed assistant general manager of the MG Car Company.

Three main points emerge: Mr. Iley was first an engineering apprentice, with technical college education, and a graduate in one of the humanities, economics. Second, he left his company after eight years to better himself elsewhere. Few firms can be quite sure that a man is as good as they think until their judgment is confirmed by others. Thirdly, Mr. Iley has had general management experience before taking up the more specialised production engineering job. He will understand better than most production engineers the points of view of the sales manager, the chief engineer, the accountant and so on. His career provides a most interesting insight into the elements of management. Top people of to-morrow are already here to-day.

Self-Supported Future

The professional man's point of view has not been a major consideration in either of the political parties' proposals for a national pensions scheme. The need for such a scheme and the voting weight of the electorate have been conveniently close together for those who have taken on the task of putting together a plan. Most thinking on the subject, and there is little reason to doubt that it will be embodied in the schemes to be announced by the Government this autumn, has been in terms of present need and present contribution for the man of modest income working for an organisation. Less thought has been given to present payment and future value of a pension for a man of larger income who will have to pay as a self-employed person. A big contribution for a future pension in an age of inflation when the insurance fund can be raided by a fairly simple piece of legislation is a poor bargain for those who would prefer to make their own pension arrangements.

Some thoughts on these issues was given by the Minister of Works last week to the High Peak Committee of the Industrial Life Officers at Buxton. Mr. Molson deplored any attempt by legislation to make a man contribute compulsorily to a scheme which would severely limit his capacity to save by other means.

Grasshopping Graduates

For long, Glasgow University has used the principle of the sandwich course for training engineering undergraduates. Its usefulness has been seriously queried by Professor J. Small in his presidential address to the Institution of Engineers and Shipbuilders in Scotland. He points out that with present demand for engineers, when every reasonably qualified engineering graduate can get a job, there is every encouragement for the undergraduate to be haphazard in his choice of training shop during the long vacation and little encouragement (as there was for long enough on Clydeside) to stick with one concern from year to year in order to stand a good chance of getting a position with them at the end of his training.

Professor Small, having looked at the prospective flow of graduates over the next few years is concerned about the poor facilities for training them systematically in practical work. He realises that the easy going attitude of undergraduates to-day forms part of the problem, but he still thinks that they are worth special treatment from industry because of their scarcity. Professor Small therefore favours the extension of the group apprentice training scheme as embodied for example in the Scottish Electrical Training Scheme. He realises that this approach puts a further call on the enlightened attitude of the large concerns. Like others he would like to see more systematic co-operation in this problem from smaller engineering companies.

Methods for the Matron

Florence Nightingale was a woman of strong character and a brilliant administrator. She left behind her a strong mark on hospital administration and her tradition is well nigh sacred. Not surprisingly, much of that tradition has not stood the passage of time and its progenitor would have been the first to accept that fact. Hospital administration is generally known to be conservative. The latest drugs are used but their supply is organised in the oldest possible way.

A publication by HM Stationery Office " Out Patient Waiting Time I " deals with one aspect of hospital administration which affects the public. Method study is also gaining advocates. Even matrons are known to be in favour—at least in principle. Some good work has been done by methods engineers in report form on improving some aspects of hospital work—generally on such matters as paper work and laundries which are far removed from the medical and nursing profession so far as professional *amour propre* is concerned. The time may be some way off before a hospital matron will be persuaded that a time study engineer knows anything about hospital beds, but his foot is in the door.

Qualified Health

The Royal Society of Health has announced a new diploma in health engineering. A distinction award will be made to outstanding candidates and the diploma will be accepted as a qualification for full membership of the society.

The new diploma will cover municipal services, administration and law. Also included will be nuclear radiation protection and decontamination. The examination can be taken in two parts the first of which will qualify for associate membership of the society. The diploma is intended to be of particular interest to architectural assistants and assistants in the departments of municipal engineers and surveyors, public health engineers and so on who do not propose to go on for a degree in engineering or one of the professional institutions' examinations.

Two Pence an Hour

The engineering employers and engineering unions took only five hours to reach agreement on the unions' wage claim. In accepting a 4 per cent increase—2*d* an hour or 7*s* 4*d* a week for skilled workers, somewhat less for semi-skilled and unskilled—the employers merely conformed to a pattern that has become established since the railwaymen were awarded 3 per cent on basic rates last May. Had no agreement been reached, it was a foregone conclusion that any arbitration tribunal or court of inquiry called upon to adjudicate on the claim would, in fact, have decided upon a 4 per cent award.

The importance of the award should not be underestimated. At a time when orders are declining and exporters meeting with increasingly severe competition, the penalty of a general wage increase will be hard to bear and even harder to absorb successfully. When all consequential increases in non-federated firms have been taken into account, together with those for female and office workers, the global increase in the industry's labour costs may well exceed £70 million. A redeeming feature is that the unions have shelved their demands for a shorter working week.

Same Difference

Shipbuilding employers were called upon " at all costs to insist on a cessation of strikes, restrictions and demarcation " by one of them, Sir Murray Stephen, chairman of Alexander Stephen and Sons of Glasgow. Sir Murray pointed out that recent strikes in British shipyards were having a most serious effect on the confidence of owners, particularly overseas owners, and leading to a loss of business. Continual strikes, argued Sir Murray, caused " serious disorganisation " and, together with the numerous restrictions and demarcations imposed on the yards by the unions, led to " over-manning and higher costs." In his view there was no surer way of bringing unemployment to the industry.

It was certainly high time that employers tackled these problems and stopped being " kicked from pillar to post."

Few will disagree with Sir Murray on the ultimate effect of strikes or restrictive practices: they combined to make British shipbuilding less competitive and less profitable; the loss of orders could only mean unemployment; the loss of profits imposed a restriction on investment in new plant and new techniques when it was most urgent to increase such investment. But the fact remains that the unions blame the management for this state of affairs and the management blame the unions. It is difficult to see how any unilateral action on management's part could overcome difficulties rooted so deep in tradition and prejudice. The way out probably lies in improving the quality of management in the shipyards and more particularly the employers' skill at handling their men. Firmness is never out of place when it is based on a demonstrably good, well thought-out, case. Unless this is so, a tough line can lead to less and less understanding, bitterness and more strikes. Even worse it may lead to the situation depicted in *Punch* last week. The scene is the launching ramp at a shipyard; a vessel has just left the slipway and promptly sunk. On the launching platform a man in a bowler is saying to another in a top hat: " That's what comes of *them* insisting on a forty hour week and *you* insisting on a scheduled launching."

Research and Development

THE AERONAUTICAL SCENE

First International Congress of the Aeronautical Sciences

Concluded from page 442, October 3

We conclude here our report on the technical problems discussed at the First International Congress in Madrid. The first part of the report, published last week, covered noise, hypersonic flight, heat transfer, materials and techniques.

Boundary Layer Control

Although boundary-layer manipulation in the form of "blowing" air to increase the circulation over landing flaps is now fairly commonplace practice for carrier-borne aircraft, the use of boundary-layer suction for overall drag-reduction has not yet "caught on." It has been likened to a "much-discussed bridesmaid who never becomes a bride. Her attractions seem to have faded a little in the eyes of some, and she seems also to be considered a little difficult to manage." She still has staunch admirers, however, who contend that "this bridesmaid appears to possess all the qualifications of an attractive bride."

The supporters of boundary layer control claim that, by maintaining extensive regions of laminar flow with consequent small drag wakes and, at the same time, small suction quantities, very great improvements in range/payload performance can be obtained, partly due to an overall increase in the efficiency of the integrated engine/airframe combination and partly due to reduced drag. The applications are, clearly, for long range transport aircraft; on the transatlantic route, it is suggested, the laminarised aircraft could show direct operating costs reduced by more than 40 per cent. In particular, boundary layer control shows greatest promise for the nuclear-powered aircraft, in which at present it is difficult to see how any worthwhile payload can be carried. In the laminarised aircraft, the improvement of lift/drag ratio (by a factor of about 2) means that, for a given all-up weight, reactor power can be reduced, and with it the shield weight, and hence the ratio of payload to all-up weight can be increased.

(Left) Hiller ducted-fan flying platform. Original design with 5 ft dia. duct.

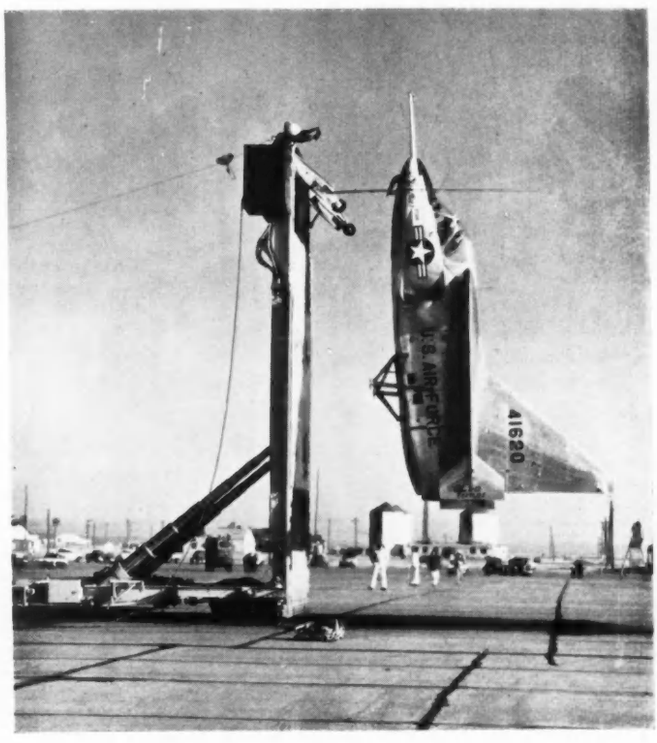
(Right) Ryan X-13 tail-sitter-type jet VTOL research aircraft preparing to land on a mobile ground service trailer.

(Below) Piasecki aerial jeep has articulated fans.

VTOL and STOL

Almost every conceivable variety of VTOL and STOL configuration —some looking extremely improbable—seems to have been under consideration, if not actually built and flying, in the United States. The reason for this widespread effort, they explain, is to provide a limited amount of information on a large number of possibilities in a short time, in order to select the best direction for the major effort. In England, this approach is simply not possible, and we have had to direct our small efforts in the VTOL-STOL field on the basis of thinking rather than indiscriminate experiment. It is interesting to see that the two approaches tend to be converging. In Britain, from the start we had no great fancy for the "tail-sitter" type of aircraft; whereas in the United States, early effort went mainly into the propeller-driven tail-sitters, the Convair XFY-1 and the Lockheed XFV-1, which are now of little interest. However, the Americans are proud of their jet-driven tail-sitter, the Ryan X-13 (powered by Rolls-Royce Avon) which takes off and lands from a ground service trailer, where it rests suspended on a hook, and which has successfully accomplished transition; it is to carry out a detailed research programme.

British VTOL effort is concentrated in the Short SC1, a "dual-propulsion type" turbojet aircraft with separate lifting and forward-flight engines. Interest in this type of layout—but on a more ambitious



Continuing Research and Development

scale—is now being shown in the United States, and a flying model is to be tested by NACA, representing a 400,000 lb airliner with 90 small lifting engines along the fuselage and two packs of four larger engines at the wing tips—somewhat like the Rolls-Royce design study, except that in the NACA model the engine packs are tiltable.

Studies of small "convertiplanes" have led in the United States to the conclusion "that an unloaded-rotor type convertiplane of multi-propeller, tractor configuration, powered by gas turbine engines would be an excellent VTOL aircraft for certain operations," in fact, the Fairey Rotodyne.

Perhaps the most interesting aspect of American VTOL investigations is the growing use of ducted fan configurations. In studies by the Vertol Aircraft Corporation and the Ryan Aeronautical Company, ducted fans submerged in the wing are proposed for vertical thrust, and turbojet propulsion for forward flight. There are also ducted-fan VTOL projects using thrust-tilting or thrust deflection, and of these the DOAK flying testbed has flown in tethered hovering flight. This aircraft has rotatable ducted fan units mounted at each wing tip.

A natural corollary of the ducted fan is the annular wing, and both Germany and France have done much analytical and analogue work on the theory, which is now in a very advanced state. Probably the most unusual VTOL project on hand at the moment is the C.450 development of SNECMA's Atar Volant, a high-speed "tail-sitter" annular wing configuration, or coleopter, to be powered by turbojet.

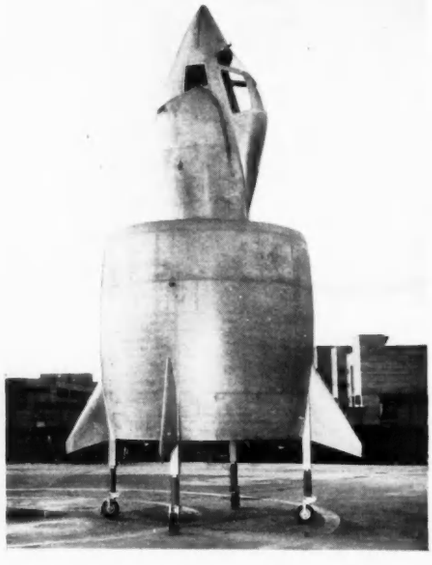
In America, the coleopter type of aircraft is represented by the Hiller flying platform, the first of which had two 2-blade contra-rotating propellers in a 5 ft diameter duct and was powered by two 40 h.p. engines mounted above the propellers. It was controlled "kinesthetically," i.e., by the pilot suitably disposing his weight to trim in the desired direction. With this form of control it has been found difficult to obtain adequate longitudinal trim for moderately high forward speed, but it is very simple for the inexperienced pilot.

The United States Army Transportation Corps has long desired "a compact vehicle with the versatility of the ground jeep combined with the ability to hover and fly forward at moderately high speeds a few feet off the ground." Contracts for such machines have now been awarded to Aerophysics Development Corporation, Chrysler Corporation, and Piasecki Aircraft Corporation. The latter company's 59 K aerial jeep will very soon be flying. It is a tandem two-shroud configuration with 7 ft 6 in dia. articulated fans driven by two interconnected 180 h.p. reciprocating engines. Control is by collective and cyclic pitch of the fan blades and by duct exit vanes.

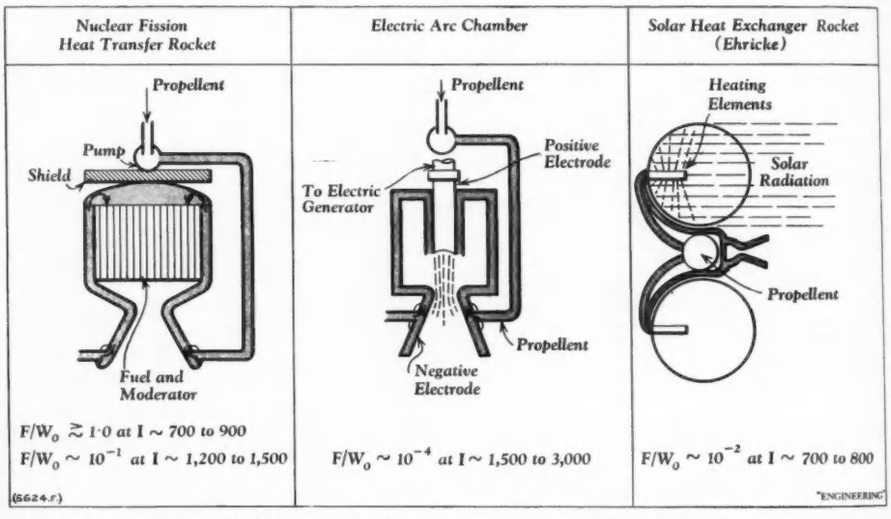
In England, although less practical experience has yet been gained than across the Atlantic, thoughts are beginning to turn to the problems that must be faced if VTOL aircraft are to be put into commercial operation. Unless undesirably uneconomical compromises are made in the design of the machine, the true VTOL aircraft will, during take-off and landing, be wholly dependent on its engines for lift, and on a complex electro-mechanical system for control. The lift-thrust/weight ratio must therefore be selected to give an adequate margin for engine failure: based on probability considerations, if up to four engines are used, it must be assumed that one will fail; if more than four engines are used (and even up to 900!), then allowance must be made for two to fail.

On the Short SC1 aircraft, the autostabiliser is a triplex unit, as described in the 12 September issue of ENGRG., page 340—i.e., each control motion has three channels, any one of which is powerful enough to operate the system on its own; their outputs are compared, and any channel showing an anomalous output can be overridden by the other two. For commercial operation, there is a feeling that the triplex auto-stabiliser is still not sufficiently reliable, and therefore a quadruplex system is favoured.

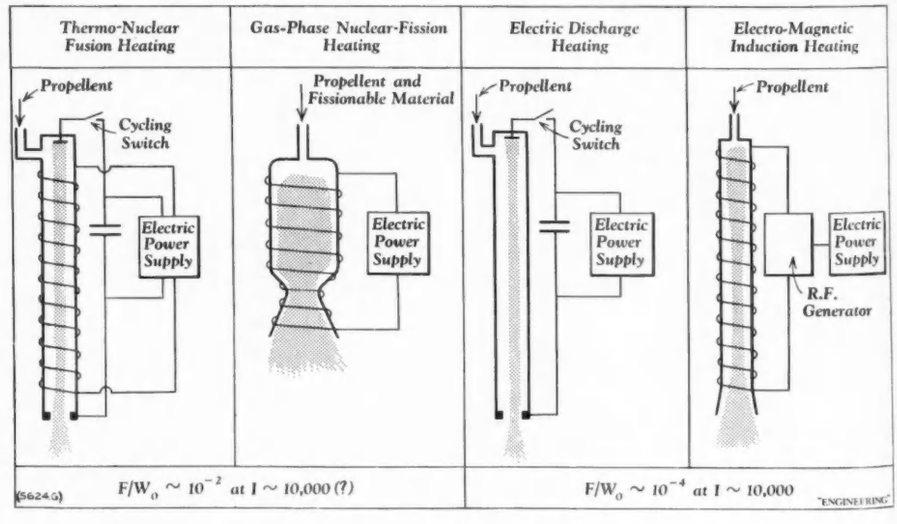
For the autopilots of conventional aircraft, too, there is a growing feeling towards the installation of multiplex systems for greater reliability and safety—particularly in view of the fact that fully automatic landing techniques are now well advanced and the day can be foreseen when such facilities will be available at every major airport. To use such



(*Above*) *The SNECMA C.450 a high speed "tail-sitter" with an annular wing configuration.*



(*Top Right*) *Group I systems limited by materials temperatures.*



(*Lower Right*) *Group II systems using magnetic (or other) containment of high-temperature plasma*

facilities safely, the pilot must be able to rely absolutely on his autopilot, and quadruplex equipment is considered to be the minimum acceptable.

Inertial Guidance

A detailed exposition of the principles of inertial guidance was one of the features of the Congress. Briefly, inertial guidance is based on the same principles as celestial-body navigation, since an inertial co-ordinate system maintains a fixed orientation relative to the stars. Inertial guidance requires (*a*) means for maintaining the orientation, with respect to inertial space, of an "inertial reference package"—i.e., a gyro-stabilised base for carrying the accelerometer—carried by the moving vehicle, and (*b*) means for accurately indicating the local direction of gravity within equipment subjected to the erratic rotations, linear accelerations, and gravitational components that accompany the operation of a moving vehicle. This is achieved by "Schuler tuning"—that is, designing the vertical-indicating sub-systems to have the proper dynamic characteristics. The output of the accelerometer is integrated to give velocity and position information. The theory of inertial guidance is completely established; the practice depends on the achievement of high-quality low-drift gyro units and accelerometers—and such units are now becoming available. For the navigation of a rocket vehicle, the inertial system gives accurate changes in velocity and position over a short-time interval—whereas radar navigation gives long-term accuracy but has a time lag. A combination of the two techniques should provide the greatest accuracy.

The implications of guidance problems on space flight was one of the points brought out. Many proposals for earth satellites and space tations have been made, and in principle they are feasible—but in practice they are unlikely to be successful unless they are studied as completely integrated systems. Guided missile experience has shown that the requirements of guidance and control profoundly affect the design of vehicle structure and propulsion systems.

Propulsion

In the field of propulsion, it seems that, for the supersonic airliner, for instance, the integrated turbojet/ramjet engine, operating on conventional fuels, will cope with the high supersonic range, and even with low hypersonic speeds if the possibilities of operating the ramjet in the detonation regime are realised. Experimental work on detonation-wave ramjets is now in progress in the United States.

Looking into the future and well beyond the atmosphere, a variety of propulsion methods are now engaging the attention of the would-be astronauts. For high-payload space journeys, as, for instance, a manned flight to Mars, chemical-propellent rockets are ruled out. Possibilities that are under consideration include the nuclear-fission heat-exchange rocket, the electric arc chamber and the solar-heat exchanger rocket. In all these types, the specific impulse is limited by material temperatures. The nuclear-fission heat-exchange rocket seems the most promising.

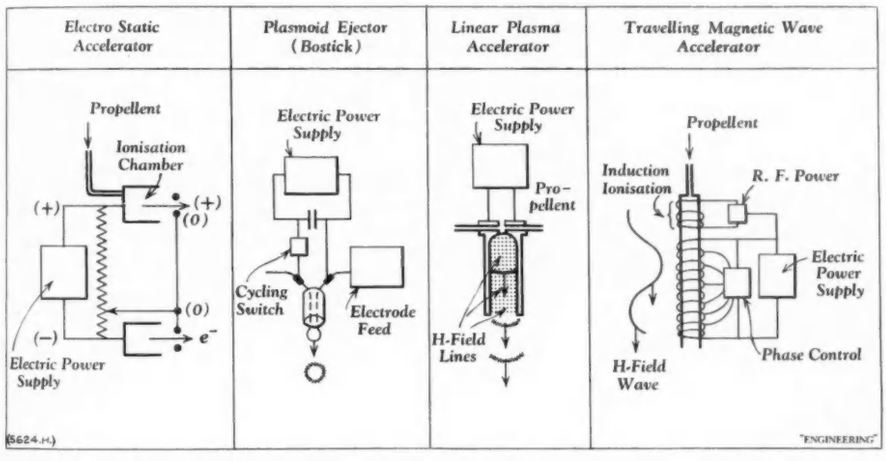
Propulsion systems which rely on heating the propellent, but in which the specific impulse is not limited by temperature, include thermo-nuclear fusion heating, gas-phase nuclear fission heating, electric discharge heating, and electromagnetic induction heating. The feasibility of the first two has not yet been established. Of the last two, the electro-magnetic induction system is more attractive since it suffers no erosion problems. Then there are a variety of possible systems in which the acceleration of the plasma jet is accomplished by electric or magnetic means rather than by heating and of which it is far too early, as yet, to assess the relative merits.

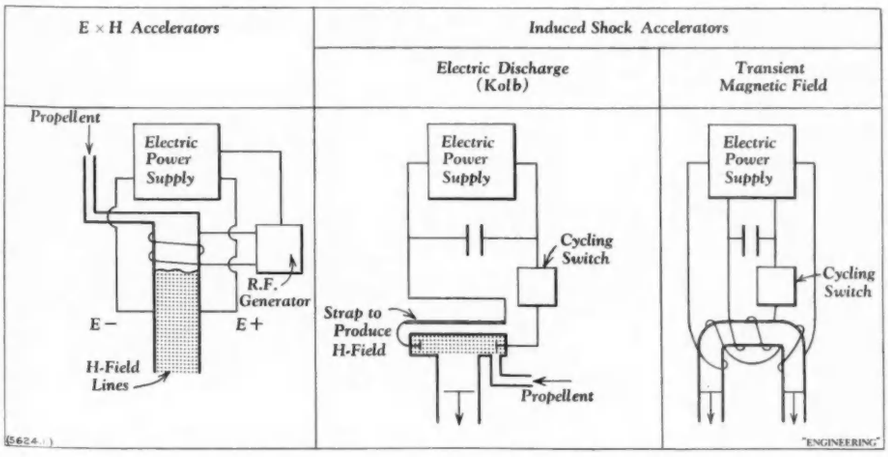
In general, however, it seems that the non-chemical propulsion systems offer the possibility of weight reductions by a factor of 10-15 over conventional chemical rockets and by 3-5 over high-energy chemical rockets. At present, the best hope for accomplishing round-trip journeys to, say, Venus or Mars, appears to lie in the development of thermonuclear rockets or gas-phase fission rockets.

The papers presented at the international congress, and the brief discussions on them, are to be published in the *Proceedings* of the First International Congress in the Aeronautical Sciences by Pergamon Press Limited, Pergamon House, 4 Fitzroy Square, London, W.1. The price will be around 5 guineas a set.

The list of technical papers submitted to the congress is as follows:

"Aerodynamic Design for Supersonic Speeds," by Robert T. Jones.
"Telecommand and Navigation," by W. H. Stephens.
"Supersonic Propulsion by Turbojets and Ramjets," by Maurice Roy.
"Newtonian Flow Theory in Hypersonic Aerodynamics," by Wallace D. Hayes.
"Dynamics of a Dissociating Gas," by M. J. Lighthill.
"Experimental Investigation of Hypervelocity Flight," by J. Lukasiewicz.
"Buckling and Post-Buckling Behaviour of Thermally Loaded Skin Panels," by A. van der Neut.
"Some Contributions to the Heat Conduction and Thermal Stress Analysis in Aircraft and Missile Structures," by Luigi Broglio.
"Representation of a Thermoelastic Vibrating System Without and With Creep in the Direction of Vibration," by R. Mazet.
"Aerodynamic Derivatives for Oscillating Three-Dimensional Wings in Transonic Flow," by Mårten T. Landahl.
"Mass Transfer Cooling, a Means to Protect High Speed Aircraft," by Ernst R. G. Eckert.
"Features of Hypersonic Heat Transfer," by R. J. Monaghan, L. F. Crabtree and B. A. Woods.
"Heat Transfer in Flows with Separation," by R. Siestrunck and J.-J. Bernard.
"Heat Transfer by Natural Convection also at Critical State Conditions," by Ernst Schmidt.
"Adiabatic Motion of a Gas in a Rotating Gas," by J. M. de Sendagorta.
"Progress in Jet Engine Noise Reduction," by F. B. Greatrex.
"Noise Research in Canada: Physical and Bio-Acoustic," by Keith K. Neely, B. Etkin and H. S. Ribner.
"Noise in Jet Transport," by William Littlewood.
"Some Studies of the Effect of Jets on Structures," by H. J. L. Le Boiteux and P. A. Lienard.
"Some Considerations of Safety in Automatic Flight Control," by A. M. A. Majendie.
"Wander Phenomena in Oscillating Gyros on Gimbal Supports," by Kurt Magnus.
"Principles of Inertial Guidance," by C. S. Draper, W. Wrigley and R. B. Woodbury.
"Some Recent Developments in Boundary Layer Control," by H. Schlichting.
"Fundamental Design Problems of Aircraft with Boundary Layer Control for Maintaining Laminar Flow," by G. V. Lachmann.
"Theoretical and Experimental Contribution to the Study of Boundary-Layer Control by Blowing," by P. Carrière, E. Eichelbrenner and Ph. Poisson-Quinton.
"The Use of Boundary-Layer Control to Establish Free Stream-Line Flows," by D. G. Hurley.
"Aeroelastic Problems on Aircraft Construction," by H. G. Küssner.
"A Review of Some Recent Developments in Hypersonic Flow," by Antonio Ferri.
"Problems of the Annular Wing Solved by Means of Rheo-electric Analogy," by L. Malavard and G. Hacques.
"Few Results of the Theory of Annular Wings in Incompressible Flow," by J. Weissinger.
"Some Contributions to the Solution of Mixed Problems of Transonic Flow," by A. A. Dorodnitsyn.
"Research on VTOL and STOL Aircraft in the United States," by John P. Campbell.
"Safety and Reliability Aspects of VTOL," by D. Keith-Lucas.
"Flight Mechanics of the Flying Power Plant Capable of Vertical Take-Off and Landing," by G. Eggers and G. Ernst.
"Structures and Materials for Finite Lifetime," by N. J. Hoff.
"Materials for Very High Temperature in Propulsion and Airframe Components," by Pol Duwez.
"Heat Resistant Materials—A Survey of Some British Developments," by D. A. Oliver.
"Telecommand and Telemetry for Pilotless Aircraft," by R. A. Leslie and P. O. Gillard.
"Transmission of Data by Radio from the US Satellites," by J. T. Mengel.
"Prospects and Limitations of Human Flight Beyond the Atmosphere—the Elusive Spheres of Interest," by Julian E. Ward and David G. Simons.
"Disorientation in Flight," by G. Melvill Jones.
"Psycho-Physiological Limits of the Human Pilot and Flying Safety," by E. Evrard.
"Propulsion Methods in Astronautics," by W. E. Moeckel.
"Physical Basis of Magneto-Hydrodynamics," by W. B. Thompson.
"A Comparison of Various Approaches to an Electric Propulsion System," by Vernon H. Blackman.





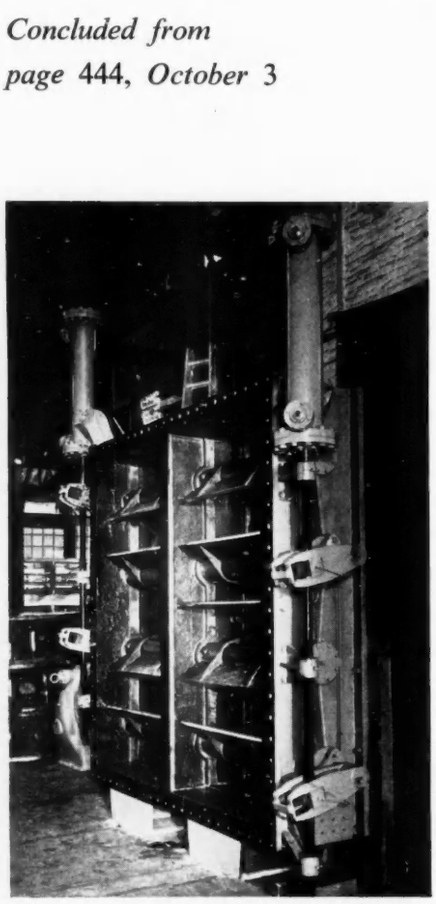
Group III (upper and lower diagrams) systems using electric or electro-magnetic acceleration (all are capable of $I \sim 10{,}000$ *sec with* $F/W_0 \sim 10^{-4}$).

***Continuing* Research and Development**

FLIGHT TESTING GAS TURBINES ON THE GROUND

Test Cells and Control System in Rolls-Royce Facility

Concluded from page 444, October 3



On Friday, 26 September, the Prime Minister opened the new engine test plant constructed by Rolls-Royce Limited at Derby at a cost of £5·8 million. The plant is designed to flight-test turbojet and turboprop engines over all the range of conditions normally met with in civil and military aircraft. Conditions of dive and climb can be simulated and air temperature can be varied from − 90° C to + 190° C with pressures from 1 to 55 lb per sq. in abs. Iceing conditions can be investigated and it is intended to add a hailstone projector at a later date. A description of part of the plant appeared in our issue of 3 October.

The large quantities of air pumped into the engine have to be removed from it together with the products of combustion—which of course are at a high temperature. Suction is provided by a series of exhauster/compressors housed in the second of the main buildings. On leaving the engine the gases are led through a water-cooled tube out of the test cells, as described in the first part of this article. The two outlets join together and feed a common primary cooler. (See Fig. 1, last week, for the complete circuit.)

The Foster Wheeler primary cooler is virtually a six drum water tube boiler in which chemically pure water is pressurised by nitrogen to 250 lb per sq. in in a closed circuit circulation. Water from the main system, circulated by three Sigmund WS-Q pumps and cooled in a Head Wrightson timber tower, is used in a heat exchanger to cool the circuit. The cooler is designed to handle gases up to 1,730° C and to cool them down to 150° C. It has a separate pumphouse which also contains the pumps for operating the Jalousy butterfly valve that controls the pressure of the air surrounding the engine in the test cell. This valve is shown in Fig. 4, in the maker's works. As may be seen it consists of horizontal vanes that are operated in parallel by oil pressure. The valve was supplied by DMM (Machinery) Limited, and the pumping equipment is by Keelavite. By its use cell pressures corresponding to heights of up to 70,000 ft can be obtained irrespective of the conditions of the air supplied to the engine intake.

Next in the line of the ducting comes the secondary cooler (also by Foster Wheeler) which is made up of four matrix elements cooled by water from the main system. At the outlet the temperature of the gases has been reduced to 70° C. The duct then continues round the site of the proposed wind tunnel and has in it the two removable sections and their Chatwood Milner bulkheads that would have enabled the connections to the latter to be made. One of the bulkheads is shown in Fig. 5. The gantry enables it to be inserted in either the main or the branch line.

In the exhauster house there are five sets, each driven by a 22,000 h.p. motor identical to the one in the input plant. Four of the sets are the same, and consist of the motor and a compressor with a volumetric capacity of 170,000 cu. ft per minute. The compressor of the fifth set is of only one-third the capacity, namely 57,000 cu. ft per min, and the set also includes a recuperating turbine for power recovery under certain circumstances. A view of the exhauster house from the main control room is shown in Fig. 6. After shut down, the sets are electrically barred for 10 hours during cooling; they can be started in 1 minute.

To allow for the many different types of test that may be required, the ductwork can be connected up (by valves) in many ways. There are said to be 138 possibilities, though the probable number that ever would be used is about 40. As an example, it is possible to run two of the compressors in tandem to supply the combustion rig, while the other three are being used to exhaust the engine test cell. To safeguard against surging a recirculation valve has been included which connects the discharge and suction sides of all compressors. This comes into operation automatically if the pressure ratio exceeds a preset maximum.

Again with the aim of reducing the setting up time of the plant, the selection of the valving for any particular type of test can be made by a "punched plate" system. The selector panel is shown in the foreground of Fig. 7. Each button is the control for one valve and a series of punched plates has been produced, one for each test arrangement, which can be laid over the buttons. The lever at the side is then pulled forward and this action presses the plate down on the buttons operating the required number. The condition of each valve whether open or shut, is indicated on the illuminated wall panel.

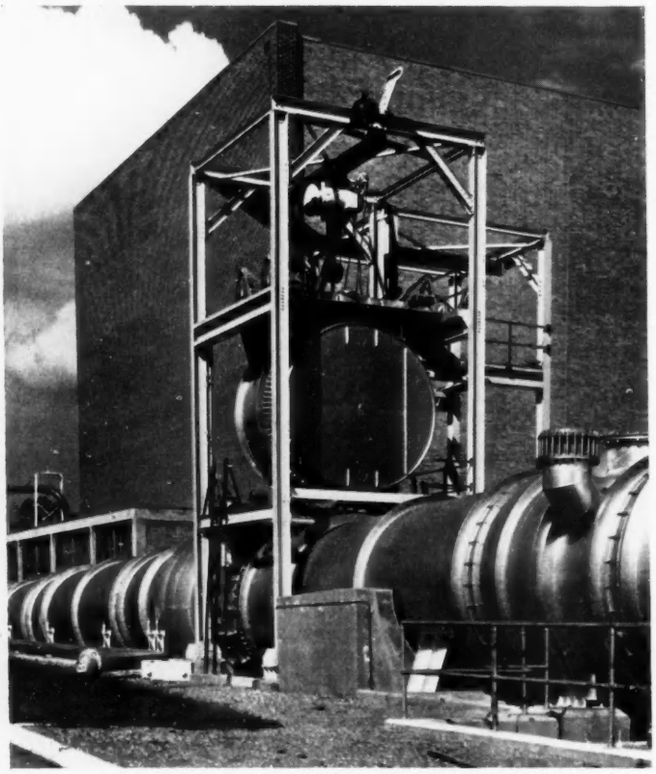


Fig. 4 (top left) A Jalousy butterfly valve with horizontal vanes is used to regulate the pressure in the altitude cell.

Fig. 5 (lower left) Provision has been made in the exhaust ducting for connections to a wind tunnel. One of the bulkheads is shown here on its handling gantry.

The valving of the input plant is also controlled by the same panel and shown on the same diagram.

Throughout the plant the valves are hydraulically or electro-hydraulically operated. In some cases rams are used instead of motors to give rapid opening or closing. The valves for the test cells are supplied from two installations of pumps, one set for the inlet side and the ventilation valves actually in the altitude cells, and the other for the outlet side. For the five valves in the first group there are four Keelavite gear pumps each delivering 50 gallons of oil per minute at 600 lb per sq. in. Three 8-gallon accumulators are included in the circuit. Oil for the circuit is supplied from a 100 gallon reservoir through six filter units.

For the second set of valves, which includes the Jalousy butterfly valve for regulating the pressure in the altitude cell, there are four pairs of pumps and five accumulators. The pumps are brought into service as the pressure falls and the order can be varied so as to spread the use among them over a period of time. Again there is a 100 gallon reservoir.

In the main control room in the exhauster building are the controller, his deputy and the charge engineer. The former sets up the plant for the test and monitors its progress, while the charge engineer is responsible for starting and running all motors and auxiliaries. Minute-by-minute running of the engine and adjustment of air supplies is worked from the control room above the test cells (shown in Fig. 8) in which are the assistant controller and the engine running staff. Operations from this room cannot commence until the chief controller turns a permissive switch.

Each cell has a separate control desk but the manometers and thermometer recorders are common. Speed of change-over from one cell to the other has been improved by the arrangement whereby a single lever changes over all the manometer connections simultaneously, as well as the thermometers. For record purposes cameras are mounted in front of each panel of instruments particularly with the idea of recording transient conditions. Arrangements have been made for all information to be transferred to punched cards which can then be treated in IBM equipment if required. Otherwise running calculations are made.

The desks supplied with the control equipment by Heenan and Froude are built up from a number of interchangeable sections and arranged so that extensions can be made later at either end. The engine controls are of the mechanical rod and lever type except at the point where they enter the cells: here Teleflex connections through sealing plates take over and join up with twist shafts on the test equipment. The controls were designed to reduce backlash and temperature effects to the minimum, and to give readings of high accuracy at temperatures ranging from + 350° C down to − 20° C and at pressures varying from full vacuum to 75 lb per sq. in.

As already mentioned, one cell is equipped for turbojet engines and the other for either turbojet or turboprop types. The two thrust-measuring stands are built on to sub-frames attached to the circular stainless-steel test-cell vessels, as may be seen in Fig. 9. The connections incorporate trunnion bearings with pins in spherical housings to prevent distortion or displacement due to cell expansion and contraction. The moving portion of each thrust stand supporting the engine is suspended by four spring-steel plates. The maximum thrust catered for is 20,000 lb, with a negative thrust of 2,000 lb.

The measuring equipment consists, in each case, of a weighing machine connected to the thrust stand by mechanical linkage. The weigher has two dials; one reading from − 2,000 lb to + 5,000 lb, and the other from + 4,000 lb to 20,000 lb. The changeover from one dial to the other is automatic. The weighing machines are located alongside the steel cells and repeat dials are installed on the remote engine-control panels. Pointer movement from one to the other is transmitted electrically.

Thrust checking gear consists of mechanical linkage, reduction levers and weights; the latter

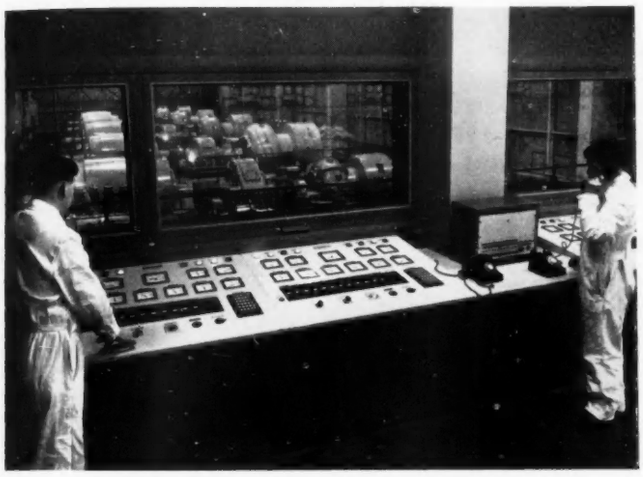
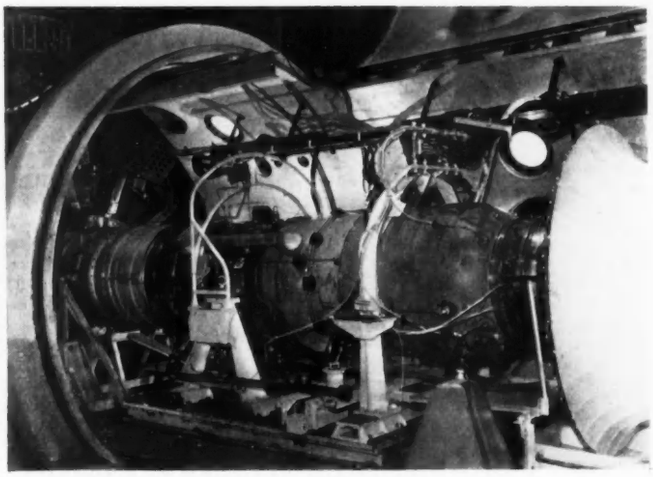


Fig. 6 The fire exhauster/compressor sets are controlled from the main room.

Fig. 7 Also in the main control room are the valve circuit selector panel (foreground) and the illuminated circuit diagram.

Fig. 8 Engine running is controlled from the second room; the vertical "windows" in the centre are groups of manometers.

Fig. 9 A Conway engine is mounted on the thrust bed with connections made to the dolly.



Continuing Research and Development

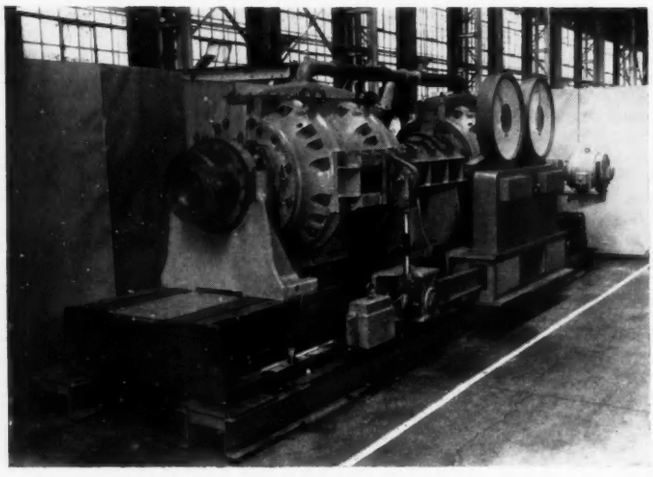


Fig. 10 For turboprop engines there is a dynamometer and weighing machine.

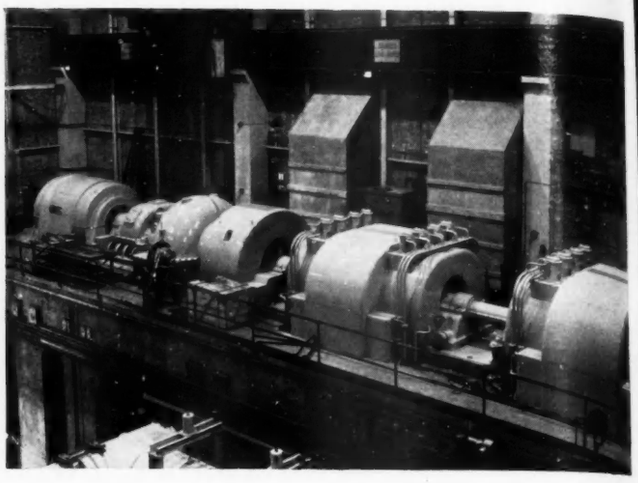


Fig. 11 This view of the main input compressor set shows the cast slab and column construction of the mounting bed.

applied outside the cell. Seals are provided at points where the linkage passes out of the cells.

The engines are placed on the thrust stands having already been mounted on an adjustable dolly with underframe in the preparation room—a time saving measure to improve the availability of the cells. The dolly was arranged initially for Conway and Avon engines but is not restricted to these.

The additional facilities in No. 2 cell, which is the one designed for testing turboprop engines, consist of dynamometers, transmission shafting, and engine supports. For torque absorption and measurement, two Heenan Dynamatic dynamometers Mark VI C, are mounted in tandem outside the cell. These, when operating together, will deal with powers up to 6,000 b.h.p. at speeds from 800 r.p.m. upwards. Torque measuring equipment consists of a weighing machine mounted alongside the dynamometers with mechanical linkage from the torque arm. Repeat dials are mounted in the control room as for the thrust stands. Torque checking gear is of the lever and weight type. The gear is shown in Fig. 10.

The transmission shaft for full dynamometer torque couples the engine to the dynamometer. It comprises a central main shaft through the end of the steel cell with a gear-toothed cardan shaft at each end. To allow for differential expansion between the cell and the transmission system, long central shaft bearings and adequate float in the gear-toothed couplings are provided. A stainless-steel tube encasing the central shaft is fitted with seals to prevent air leakage. Owing to the varying conditions of pressure and temperature along the length of the main transmission and cardan shafts, two lubricating systems have been provided; one serving the dynamometer end and the other the engine end. Each system consists of an oil storage tank, main circulating pump, filter, heat exchanger and the necessary pipework, and valves. Scavenge pumps are provided in the oil return lines.

The plant is intended for fully automatic running using magnetic amplifiers working on signals from the pressure and temperature sensing elements, and comparing them with the set conditions. It is also possible to arrange for a series of conditions to be followed in sequence according to a chosen programme simulating some particular aspect of an aircraft's flight. Manual operation of all valves is also possible, from both the controller's and assistant controller's desks.

To supply power to the plant, there is a separate high voltage sub-station which is fed from the East Midlands Electricity Board through the grid. Current is received at 33,000 V and transformed to 11 kV for the six 22,000 h.p. synchronous motors. Power for the ancillary services is derived from a different source of supply at 6,600 V and transformed as required. The total estimated demand of the plant is 60 MW—equivalent to the load of a small town. It is not expected that the demand will govern the hours during which the plant can be run, but there is a maximum demand clause, with penalty for excess, in the contract. At present, operating has been divided into two shifts, one mainly concerned with preparation, change-over of engines, bulkheads and the like, and the other with actual test running. This is likely to be modified when the second cell is brought into use. Noise has been kept down by extensive use of sound insulating material.

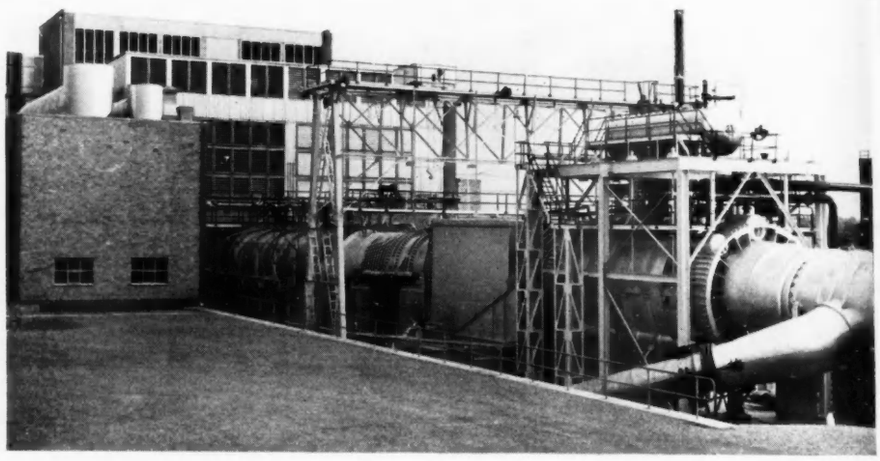


Fig. 12 From the test cells in the background, the hot exhaust enters the primary cooler (foreground). The descending pipe is a by-pass from the input compressor. The building on the left houses the compressor test rig.

Water for all purposes, including cooling and domestic, is supplied from the town mains to a 750,000 gallon reservoir under the main cooling tower. There is also a water-treatment plant on the site.

One of the problems that faced the civil engineer was that part of the site is on good boulder clay while the rest is on soft red clay, about 30 ft deep, lying over marl. Consequently, a certain amount of piling was needed, the piles ranging about 35 ft long. The motor/compressor sets in both the input and exhauster buildings are mounted at first floor level on separate slabs. The columns on which these slabs rest are of reinforced concrete and do not contain any structural steel. With the exception of one which was too large, all the slabs were cast in one pour, and were post-tensioned. The one for No. 6 machine, however, had to be cast in two pours giving rise to a tensioning problem. This was solved by forcing the supporting columns apart with jacks, pouring the two parts and then removing the jacks. The resultant inward movement of the columns pinched the slabs together and provided the necessary forces. Some idea of the construction can be gained from Fig. 11 which shows the set for the engine supply. The primary cooler is seen in Fig. 12.

The exhaust ducting also presented problems. Since the risk of an explosion had to be considered, provision had to be made for the resulting horizontal forces, which at a bend might amount to some 600 tons. As most of the ducting runs about 12 ft above ground level there was a large overturning moment to be allowed for in the construction of the supports and anchorages. Architects for the scheme were Messrs. Ramsey, Murray, White and Ward; consulting civil engineers, R. I. James and Partners; and consulting engineers, McLellan and Partners in association with Merz and McLellen.

Marketing

CHALLENGE TO ADVERTISING

British advertisers are preparing themselves for a period of intense activity as competition increases and trade becomes more free. This was stressed repeatedly at the third conference organised by the Advertising Clubs and Associations of Great Britain at Harrogate under the title "A Year of Challenge." Mr. John Oldham, chairman of Oldham and Sons, urged the managing directors to concern themselves personally with the expenditure of their firms' advertising budgets. "There are many things which a managing director can depute to other people," he said, "but advertising in my view is not one of them."

Mr. W. T. Wren, chairman of Allied Ironfounders, emphasised the importance of good design in competitive markets. Manufacturers from West Germany, Italy and Scandinavia had been studying the changing needs of consumers and finding "excellent answers." The impact of their far-sightedness on British industry could be severe, particularly "if and when the Free Trade Area operates." Mr. Wren considered that the industrial designer played a major part in the search for sales appeal. In his view, "advertising agents and those concerned with publicity can do a lot of work on manufacturers to improve their designs." He quoted the Italian typewriter, Olivetti, as an excellent example of what an overall design policy can achieve in terms of sale, both at home and in export markets.

Other speakers linked public relations and propaganda with advertising. Lord Luke, president of the Advertising Association, stressed the great responsibility which rested on advertisers because "those concerned in the production of ideas are doing the public's thinking for them."

There is also a need for caution—for what Mr. E. Luscott-Evans of the Birmingham Publicity Association called "sensible, well planned, and co-ordinated public relations for advertising." Otherwise attacks on the profession, will increase, and it will become less able to play its part as "the voice of industry."

More Price Cuts

The prices of more engineering raw materials and products have fallen recently including stainless steel, plastics and electric motors. Firth-Vickers Stainless Steels Limited, who are Europe's largest producers of ferritic stainless-steel strip—known as Fl 17 and used mainly in motor vehicle manufacture—announced price reductions for sizes up to but not including 15 in wide. These will vary according to the thickness and width of the product from £15 to £35 per ton. The company expect the lower prices "to stimulate the use of stainless steel in the motor industry".

Epoxy resins made by Ciba (ARL) Limited (formerly Aero-Research Limited) are to be sold at substantially reduced prices. Ciba announced that these reductions followed immediately "the completion of a new epoxy resin factory at Duxford with a greatly increased production capacity." Further reductions in the price of electric motors, this time variable speed a.c. commutator types (Schrage Type CHT) have been made by British Thomson-Houston in standard ratings up to 20 b.h.p. Prices are reduced by 10 per cent, being "a natural outcome of extended manufacturing facilities to meet a vastly increased demand."

Flying Sales Drive

A novel approach to selling engineering products is being tried by the Balfour group of companies, who manufacture a wide range of chemical process plant. Two young sales engineers, R. J. Hannaford and Gordon Pearce, left Southend airport in a small private aircraft for a 22,000 mile tour of Africa. Their aim is to bring to the notice of developing African industry the very wide range of products the group have to offer, which include glass-lined storage and processing vessels, gas holders, reactors and equipment for the chemical and petroleum industries, and process plant for the expanding citrus fruit trades.

Appointments have been arranged in eighteen principal towns with the group's agents in South Africa and Rhodesia, and altogether they will touch down at 41 important points on the outward and return journeys. The Board of Trade are actively supporting the trip and have arranged interviews with government officials in south-west African territories. If the two men are able to interest any firms in a really large project, specialists from Balfour's will be flown out from Britain. Hannaford and Pearce will be back home in time for Christmas, having logged up two hundred flying hours.

Canadian Confidence

The feeling that Canada is on the path to recovery is gaining ground, despite the decline in British exports during August. Exports to Canada totalled £13·9 million, £500,000 less than in July, and in the first 8 months of the year exports were 6 per cent below the level of the corresponding period of 1957. Nonetheless, confidence in the soundness of the economy is reflected in the bookings for the National Industrial Production Show of Canada to be held in Toronto in May, 1959. They are reported to be some 55 per cent ahead of the last show at this time, and arrangements are already being made for the provision of additional space.

The main reason for the heavy bookings is the satisfaction on the part of exhibitors in the 1957 show. Many of them have doubled or trebled their bookings. This applies particularly to manufacturers of machine tools and heavy industrial equipment. The exhibition will have a distinct technical character. New methods and techniques will be discussed by prominent speakers at conventions organised by the American Society of Mechanical Engineers and the Canadian Welding Society. The emphasis will be on technical progress and on the latest developments in materials and methods of manufacture.

Cheaper Hire Purchase

Several engineering companies, among them Massey-Ferguson and David Brown, have announced cheaper rates of hire purchase since the dramatic intervention of the banks in the field of consumer lending. Massey-Ferguson reduced their charges—in conjunction with the British Wagon Company—for the first time on 1 September and again on 23 September. The rates are 6 per cent for 12 months, 9½ per cent for 18 months and 13 per cent for 24 months. They are taking advantage of the removal of Government controls and are quoting 16½ per cent for 30 months and 20 per cent for three years. The initial deposit period is reduced to 10 per cent for a period of up to and including 24 months, and 15 per cent for periods of 30 and 36 months. These terms apply to all Massey-Ferguson tractors, combines, balers and implements.

David Brown Tractor Division announced similar reductions on their agricultural tractors and farm machinery and there is little doubt that the lower rates and extended terms will shortly apply to the bulk of engineering products sold to small firms or individuals. The reduction of the minimum deposit on household appliances and radio and television sets from 50 per cent to 33⅓ per cent is expected to have a considerable impact on sales. The complete removal of restrictions on motor and pedal cycles, and heavy commercial vehicles, should greatly assist the recovery of these industries in the home market. Caravans were booming already and the removal of restrictions should further improve their popularity.

Although it is too early to gauge the effect of these measures on sales, there is no doubt that competition is growing among hire purchase companies. Charges may very well fall even further.

All the World's Farmers

Service engineers abroad have to be not only competent at their job, single handed, but understanding and tolerant of the strange customs they encounter. In the Middle East a serviceman may find his van's path barred by angry farmers armed with rifles who consider that their requirements are especially urgent. Or he may be proffered a sheep's eye as a delicacy before being allowed to repair a tractor. Dense jungle, desert, unbridged rivers, dust and heat, the lack of roads, are conditions he must learn to master. In some cases the only practicable means of transport may be either a helicopter or a mule, and in Malaya complete tractors have had to be flown in sections into jungle clearings.

Such problems were discussed at a conference held recently by Massey-Ferguson in Warwickshire, attended by delegates from their service organisations in America, Europe, Africa, India and the Far East. Special service tools were demonstrated and lectures given by specialists on subjects ranging from the problems of providing service in underdeveloped countries, the application of mobile radio telephones in agriculture and the deployment of emergency repair vehicles to the general administrative problems connected with servicing farm machinery.

Plea for Fair Trading

Price cutting and below-the-belt trading practices are threats to the prosperity of the engineering industries. This was the basic theme of an address by the sales director of Firth Brown Tools Limited, Mr. T. H. Burleigh, at a luncheon meeting of the Association of Engineering Distributors. The sudden change from a sellers' to a buyers' market, with too much capacity chasing too few goods and the lack of salesmen with experience of competitive conditions, could easily lead to a free-for-all with no possible winner.

Mr. Burleigh suggested that manufacturers and merchants should co-operate in maintaining reasonably stable prices. This did not mean going on as before, but the joint formulation of realistic trading terms. Unless this were done quality would suffer and engineering tools would be sold for jobs they were unfitted to perform. Servicing would have to be cut, stocks would be reduced below workable levels and the user would suffer as much as the retailer, the merchant or the manufacturer. Firth Brown Tools sell their purpose-made tools directly to the customer, and have a large sales and service organisation. But distribution of their standard range had recently been organised through four main depots where large stocks are held. This arrangement should enable distributors to obtain their supplies quickly and obviate their own need to maintain substantial stocks.

Members of AED have a technical function to perform, in advising customers on the best tools, machinery and equipment to install, and how to use and maintain them. They cannot do this efficiently under the conditions of a price war. It is therefore vital to maintain order and this can be done without infringing the Restrictive Practices Act provided there is goodwill and common sense all round.

Special Article

VEHICLE SPEEDS AND DELAYS

Results of Field Studies in Newcastle upon Tyne

By T. E. H. Williams, PH.D., M.SC., A.M.I.C.E., A.M.I.STRUCT.E.*

THE statistical results of field studies of vehicle speeds and delays provide a basis for evaluating the effect on traffic flows of changes in road layout or methods of traffic control. Examples of their use are where alterations are proposed for roads in respect of width, gradient or curvature; where new traffic (light) signals are being considered; or alterations to phases or cycles of traffic signals are under consideration; where enforcement of speed limits is proposed; and for road intersections with high accident records.

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The present article describes two methods of measuring the speeds of vehicles. One method, by use of an Enoscope, is suitable for use with traffic of low density. The other method, Moving Observer, is particularly suitable with congested traffic flows. A method of calculating the magnitude of average delay per vehicle at road intersections with two-phase traffic signals is also given. Methods of analysis of the collected statistical data and their presentation in simple graphical forms are illustrated from the results of field studies in Newcastle upon Tyne.

Instantaneous Speed.—The spot speed of a vehicle is defined as its instantaneous speed at a specified point on a road. For practical purposes, this means the average speed over a very short length of road. All manual and semi-automatic methods of measuring spot speeds are based on the time interval between the instant of passing two detectors set a short distance apart on the carriageway. The most common form of detector is a hollow rubber tube which is connected to a recording device at the roadside or laboratory; the pressure of vehicle wheels on the tube sets up an air pulse which closes a diaphragm switch in an electric circuit and the closure of the switch results in a signal from a flashing beacon, a mark on the chart of a pen-recorder or a reading on an electronic device.

A completely automatic method of measuring spot speeds is the Electromatic Speed Meter or Radarscope. This device is based on the Döppler principle of reflected sound waves from a moving object. A beam of sound waves is transmitted towards an approaching vehicle; the speed of the vehicle in relation to the meter alters the length of the sound waves returned to the receiving unit of the meter; the meter dial is calibrated to read speeds directly. An autographic pen-recorder connected to the receiving unit gives a permanent record of the vehicle speed.

Photography has also been used to record traffic movements. A fixed time interval between exposures enables the speed of vehicles to be calculated by projecting the film on a screen covered with a grid of distances to correct scale.

Journey Speed.—Journey speed or overall travel speed is defined as the speed over a specified length of road, being the distance divided by the overall travel time, including delays. A knowledge of the values of this index is of importance in studies of traffic congestion in city streets; studies of vehicle costs and road construction costs; design traffic volumes for new roads.

A vehicle is driven along the test route at the speed of the main traffic stream and a record is kept of the time at the instant of passing specific reference points along the route. The distances between the reference points are measured and the journey speeds calculated.

Another method consists of recording the registration number of vehicles which enter and leave the test route. Photographic methods are also suitable for use on short routes.

Enoscope Method.—In Newcastle upon Tyne, speed studies were carried out on the Great North Road (A1) in the city suburbs where the volume of two-way traffic was 989 vehicles per hour on a single four-lane carriageway. The apparatus used for the tests were two Enoscopes—simple mirror periscopes—which consisted of plane mirrors of size 14·2 in by 10·0 in rigidly fixed in L-shaped housings with open ends. The Enoscopes were mounted on separate tripods and erected on the same side of the road, 176 ft apart and facing each other. An observer, equipped with stopwatch, standing midway between the two Enoscopes was able to observe to the nearest 0·1 sec the time taken

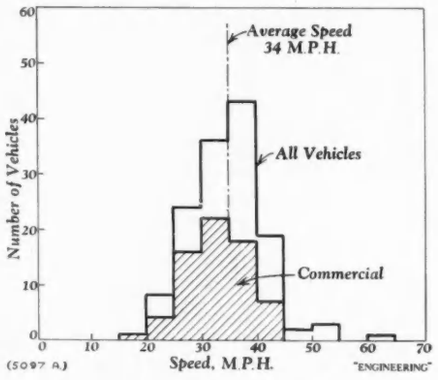


Fig. 1 Southbound traffic.

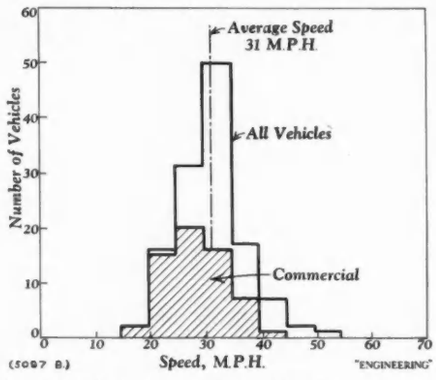


Fig. 2 Northbound traffic.

Figs. 1 and 2 Histograms of vehicle speeds on the A1 trunk road outside Newcastle. The northbound traffic—with the lower speeds—is leaving the slow-speed city area; the faster southbound traffic is approaching the city.

TABLE I.—*Vehicle Speeds on A.1*

Speed group, m.p.h.	Mean speed, m.p.h.	Northbound			Southbound		
		No. of vehicles	Distributive per cent	Cumulative per cent	No. of vehicles	Distributive per cent	Cumulative per cent
15–19	17	2	1·6	1·6	1	0·8	0·8
20–24	22	16	12·7	14·3	8	5·8	6·6
25–29	27	31	24·6	38·9	24	17·5	24·1
30–34	32	50	39·7	78·6	36	26·3	50·4
35–39	37	17	13·5	92·1	43	31·3	81·7
40–44	42	7	5·5	97·6	19	13·9	95·6
45–49	47	2	1·6	99·2	2	1·5	97·1
50–54	52	1	0·8	100·0	3	2·2	99·3
55–59	57	0	0	—	0	0	99·3
60–64	62	0	0	—	1	0·7	100·0
Totals	—	126	100	—	137	100	—

TABLE II.—*Summary of Statistical Indices*

Index	Northbound m.p.h.	Southbound m.p.h.
Average	31	34
Median	30	34
Mode	30	38
85th Percentile	36	40
15th Percentile	24	27
Pace	25–35	30–40
Range	15–50	19–60
Standard deviation	6·1	6·9
Coefficient of variation	19·7	20·3

TABLE III.—*Volumes and Classifications of Vehicles*

Type of vehicle	Northbound vehicles per hr	Southbound vehicles per hr
Pedal cycles	6	6
Motor cycles	7	18
Cars and taxis	232	269
Vans	75	64
Lorries	94	94
Motor buses	49	45
Trolley buses	14	16
Total	477	512

by vehicles to traverse the 176 ft. The mirrors served to reflect the image of the vehicles through 90° to the observer's line of sight.

To obtain an unbiased sample, observations were made at 15 seconds interval; each tested vehicle was classified. A classified count of the total traffic was also made during the test period.

A total of 137 southbound vehicles and 126 northbound vehicles were observed. The significance of these results is best appreciated from the values of statistical indices which were used to condense into a few numbers what were the important aspects of the test results.

The average speed is the arithmetical mean of the spot speeds for all vehicles in the sample, the total sum of observed speeds divided by the total number of observations. The median speed is the central or 50th percentile speed; it is exceeded by as many test results as fall below it. The mode speed is the most popular speed or group of speeds; it is the value which occurs most frequently in the sample. These three values are measures of central tendency.

The 85th percentile speed is the speed at or below which 85 per cent of the vehicles travel. The 15th percentile speed is the speed below which 15 per cent of the vehicles travel. In the United States of America the former index is used as a guide when introducing speed limits; the latter index is considered to represent the upper limit for slow moving vehicles which would probably be a source of obstruction to the main body of vehicles in a traffic stream. The 10 m.p.h. pace is the 10 m.p.h. speed range which contains the largest percentage of results in a sample of spot speeds. These three values are design indices.

The range is the difference between the highest and lowest speed in the batch of test results. The standard deviation is the root mean square of the differences between each of the speed values in the test batch and the average speed. The coefficient of variation is the standard deviation expressed as a percentage of the average speed. These three indices are measures of the amount of scatter of the test results about the average speed. A high value of coefficient of variation indicates a wide scatter and vice versa.

Table I gives the grouped results for the Enoscope studies in Newcastle. The histograms, Figs. 1 and 2, and cumulative curves, Fig. 3, show these results in graphical form. The histograms show the number of observations plotted in group intervals of 5 m.p.h. The cumulative curves show the upper limit of each group of results plotted against the cumulative percentage of vehicles travelling at or below that

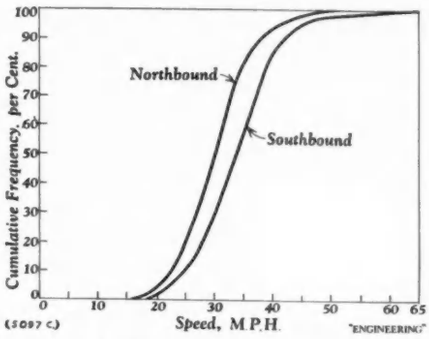


Fig. 3 Cumulative vehicle frequency, per cent, obtained from Figs. 1 and 2.

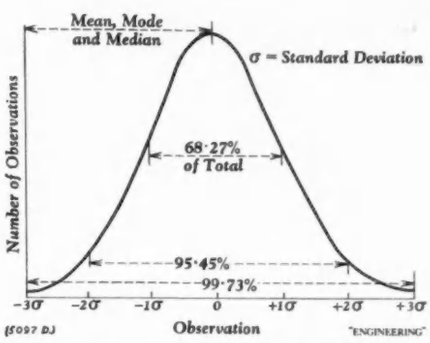


Fig. 4 A normal distribution of speed values, where there is no hindrance to smooth traffic flow.

speed. The values of the various statistical indices, derived from these graphs or by computation are listed in Table II. The volumes and composition of flows during the test periods were as detailed in Table III.

In general, these results show that the traffic approaching the city (southbound) travelled at higher speeds than those leaving it. The close agreement between the values of average, median and mode speed, particularly for the northbound traffic, indicates a symmetrical or normal distribution of results. A normal distribution of speed values, as shown in Fig. 4, is usually obtained from traffic which is free of congestion on a road without traffic light signals. In towns, the distribution of traffic speed values is not symmetrical; the degree of skewness is controlled by the amount of congestion or obstruction.

The higher speeds of the southbound traffic compared with the northbound traffic would be the result of travelling in open country on a road with no speed limit before reaching the test area. Most of the northbound vehicles had probably passed through the central business district of Newcastle and the drivers were adjusted to slower speeds. This evidence supports the argument that an abrupt change from no speed limit to a 30 m.p.h. limit is not immediately effective; to ensure a good response from drivers, speed zones should be located around built-up areas. The speed limits within these zones should be progressively increased in the direction of open country.

Moving Observer Method.—The overall journey speed of traffic passing through the central business district of Newcastle was measured by the moving observer method. A vehicle was driven at the speed of the main traffic stream over a distance of 1·25 miles between Park Terrace on the North Road and the southern end of Tyne Bridge. A total of ten runs was made in every hour between 0700 and 1900 hours over a period of eight months. The average journey time for each batch of ten journeys was plotted against travelled distance, in the manner shown in Figs. 5 and 6.

In these two distance-time graphs the slope of each broken line represents a particular speed; the full lines show the test results for four hours in a weekday including the hours of maximum and minimum delay. These graphs clearly illustrate that the overall journey speed may consist of component speeds over particular parts of the journey which are greater or smaller than its own value. For southbound traffic (Fig. 5) between 7 a.m. and 8 a.m. the overall journey speed was 18·5 m.p.h. and the component speeds were 25, 18, 16, 8, 13, 22 and 28 m.p.h. The same graph illustrates the influence of heavy pedestrian flows during popular shopping hours on traffic speeds; the maximum delays in Northumberland Street and Pilgrim Street occurred between 2 p.m. and 3 p.m. The points of congestion are readily observed from the abrupt changes in slope of the test curves.

Traffic Delays.—Traffic light signals are a major source of traffic delay at intersections in urban areas. The magnitude of the average delay per vehicle on each arm of an intersection is an index of the efficiency of the signal settings. A method of calculating the optimum cycle time for minimum traffic delay at intersections with traffic lights has been developed by the Road

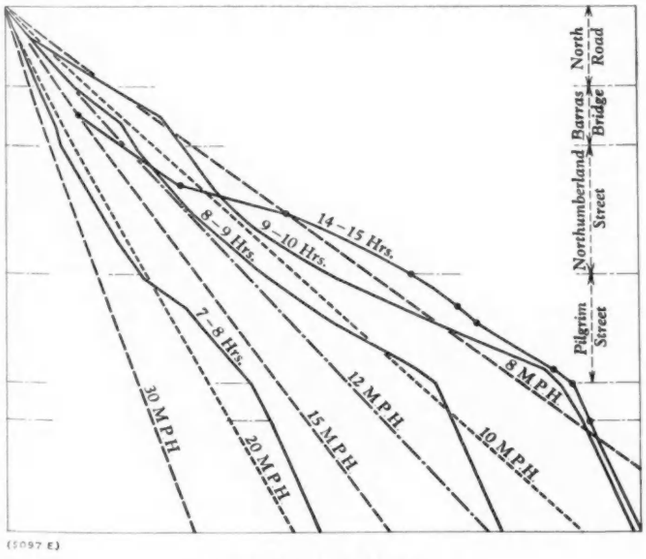


Fig. 5 Southbound traffic.

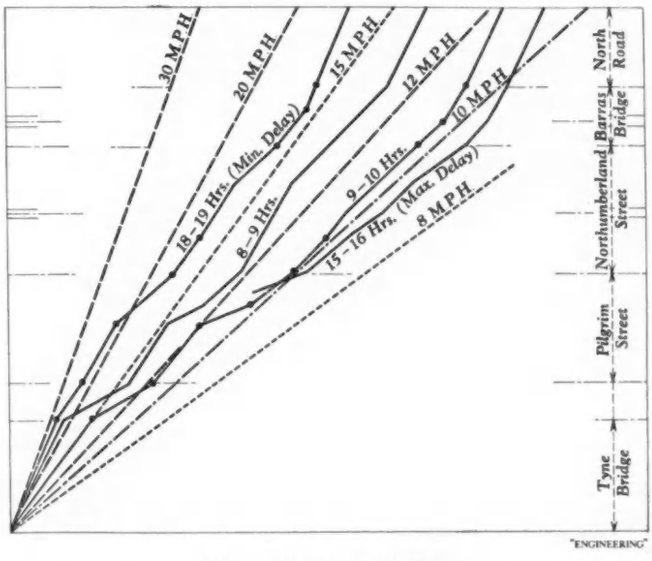


Fig. 6 Northbound traffic.

Figs. 5 and 6 Traffic flow speeds in periods of minimum and maximum delay on the A1 trunk and in a central business district of Newcastle upon Tyne. The plotted values are the mean of 10 runs made for the hour concerned. The data were obtained by the moving observer method.

Continuing

Vehicle Speeds and Delays

Research Laboratory (RRL) of Great Britain. It is based upon their formula for the average delay per vehicle which was computed under laboratory conditions by means of an electronic simulator. Traffic data, in the form of random numbers, were fed into the computing machine which was made to simulate the arrival, queueing and departure of vehicles. The formula reads as follows:

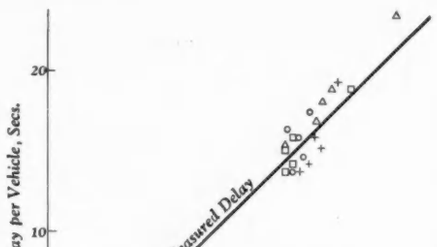
$$d = \frac{c(1-\lambda)^2}{2(1-\lambda x)} + \frac{x^2}{2q(1-x)} - 0{\cdot}65\left[\frac{c}{q^2}\right]^{\frac{1}{3}} x^{(2+5\lambda)}$$

where d = average delay per vehicle on the particular arm of the intersection; c = cycle time; λ = proportion of the cycle which is effectively green for the phase under consideration; q = actual traffic flow; s = saturation flow; and $x = q/\lambda s$ the degree of saturation.

The saturation flow, s, is the maximum rate at which vehicles can discharge from a particular iimb of the intersection, i.e., " bumper-to-bumper " flow. In a fully saturated green period, traffic moves at the saturation flow for an effective green time which the RRL has found to be approximately two seconds less than the green plus amber time. This is explained by the time lag between the instant of showing amber and the first vehicle to come to a stop at the stop-line.

In Newcastle, field studies of traffic delays at intersections with fixed-time traffic signals were carried out to determine the values of average delay per vehicle for various lengths of cycle and volumes of flow. The method used measured the overall or journey delay for a sample of vehicles from the total flows. Fixed points of reference were chosen on each limb of the intersection to be studied at a sufficient distance from the stop-lines to ensure that they were clear of any queues. Vehicles were selected at one-minute intervals and the time taken to pass between two of the chosen reference points, including the crossing of the intersection, was recorded. Some of the observed vehicles cleared the intersection without any delay; their journey-times between reference points gave the average free-running times for the various movements. The subtraction of the average free-running time from the actual journey times gave the values of the delay per vehicle.

Fig. 7 shows the results obtained at an intersection of symmetrical lay-out where the cycle length was fixed at 46 seconds and the flows on the four limbs varied from 520 to 1,100 vehicles per hour. The measured overall delay was plotted against the theoretical delay, calculated from the RRL formula. It is seen that good agreement was obtained between the two sets of values.



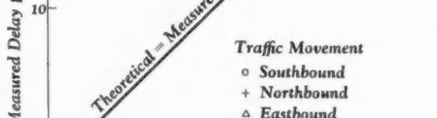
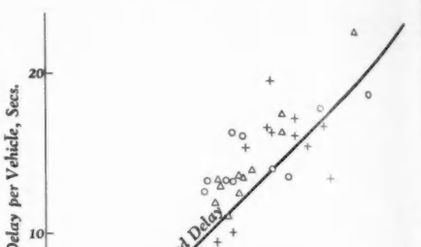


Fig. 7 Symmetrical.



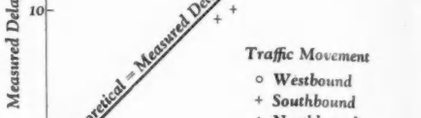


Fig. 8 Asymmetrical.

Figs. 7 and 8 Study of vehicle delays due to traffic lights at symmetrical and asymmetrical road intersections. The observed delays are shown to be closely similar to those expected from a theoretical analysis.

Fig. 8 relates to an asymmetrical intersection with limbs of unequal widths. It also has two pedestrian refuges which are eccentrically located on the north-south limbs. The signal cycle was fixed at 58 seconds and traffic flows varied from 1,000 to 1,800 vehicles per hour. A reasonable degree of agreement was obtained between the measured and theoretical delays.

The results of these field studies have proved the validity of the Road Research Laboratory's delay formula for intersections with four limbs without staggers and heavy turning movements. The calculated values of average delay per vehicle showed good agreement with measured values.

Acknowledgment.—The field data quoted in this paper were collected by post-graduate students of Highway Engineering and Traffic Studies, Department of Civil Engineering, University of Durham, King's College, Newcastle upon Tyne.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Machine Tools

Press Brake Tools. THE BRONX ENGINEERING COMPANY LIMITED, Lye, nr. Stourbridge. The " Press Brake Tool Manual " contains descriptions of bending, punching and notching tools for use in press brakes. Notes are included on loads required and the methods of forming particular shapes.

Boring Head. GAMET PRODUCTS LIMITED, Hyth, Colchester. Automatic boring and facing head up to 13·5 in diameter. Maximum carriage movement 1·25 in; three feeds, 0·0025, 0·005, and 0·0075 in per rev. Leaflet.

Machine Tools. KRIESCHER & CIE, Lindemannstrasse 31, Düsseldorf-Zoo. New and second-hand machine tools of all descriptions and makes; priced catalogue.

Guillotine. BROOKES (OLDBURY) LIMITED, Oldbury, Birmingham. Hydraulic guillotine shears with capacities from 6 ft by ¼ in to 12 ft by 1 in. Leaflet.

Cutting-Off Machines. BROOKES (OLDBURY) LIMITED, Oldbury, Birmingham. Tube cutting-off machines for tubes of outside diameters from 1 in to 5 in; hand feed or fully automatic. Leaflet.

Press Lubricator. STANLEY JEVONS TOOL COMPANY, Avon Street, Birmingham 11. " Jaco " automatic lubricating system for press work and deep drawing. Air operated, capable of up to 250 cycles per minute. Leaflet.

Laps. B. O. MORRIS LIMITED, Morrisflex Works, Briton Road, Coventry. " Macolaepp " handlaps, wheels and paste for lapping cutting tools. Used instead of diamond laps. Leaflet.

Turret Punch Press. DOWDING AND DOLL LIMITED, 346 Kensington High Street, London, W.14. New model British Wiedemann turret punch press, of 80,000 lb punching pressure, 20 to 28 stations, and 33 in throat depth. Illustrated leaflet.

Power Electricity

Lifting Magnets. W. E. BURNAND AND SON LIMITED, Duo Works, Shoreham Street, Sheffield, 1. Lifting magnets with their associated controllers and cable drums, bi-pole or circular types with lifting capacities up to 67,200 lb. Illustrated brochure.

Fractional H.P. Motors. CROMPTON PARKINSON LIMITED, Crompton House, Aldwych, London, W.C.2. Series T fractional horse-power motors, three phase, split phase, or capacitor start from ¼ to 0·95 h.p. Foot, flange or resilient mountings interchangeable with NEMA standards. Leaflet.

Portable Safety Lamps. NIFE BATTERIES LIMITED, Redditch, Worcs. Hand, head and portable battery-operated lamps for use under all conditions. Various leaflets.

Wiring Accessories. J. A. CRABTREE AND COMPANY LIMITED, Lincoln Works, Walsall. Wall switches, joining boxes, bell pushes, ceiling roses, miniature circuit-breakers and the like for 250 and 500V circuits. Catalogue No. 1194.

Electric Fencing. WOLSELEY ENGINEERING LIMITED, Electric Avenue, Witton, Birmingham, 6. Electric fencing as applied to wild animals, such as warthogs, baboons, elephants and giraffes, as well as foxes and rats. Leaflet.

Power Transformers. GRESHAM TRANSFORMERS LIMITED, Hanworth, Feltham, Middlesex. Descriptive catalogue of power and instrument transformers written in English, French, German and Spanish.

Alternators and Generators. CROMPTON PARKINSON LIMITED, Crompton House, Aldwych, London, W.C.2. Alternators and generators with outputs up to 1,500 kVA; self-regulating or separately excited. Brochure.

Book Reviews

ALL SCIENCE SURVEYED

Van Nostrand's Scientific Encyclopedia. *D. Van Nostrand Company Limited*, 358 *Kensington High Street, London, W.*14. (220*s*)

The Van Nostrand Scientific Encyclopedia has, since its first appearance twenty years ago, acquired a deservedly high reputation as the most comprehensive single volume work of reference of its kind. The second edition was published in 1947 and, in order to cover the major advances made in both the biological and the physical sciences since that date, the entire work has been considerably enlarged, completely revised and reset for the present third edition.

Its 1,839 pages now contain over 14,000 entries with 1,400 illustrations and 12 plates in colour. It is sumptuously produced and furnished with a thumb index. Fourteen new contributors have been added to the original twenty-two for this edition and among them are four from this country. As a general rule individual contributors have assumed responsibility for the entries under each of the two dozen or so main divisions of the subject matter ranging from aeronautics to zoology, and in this way a substantial uniformity of treatment has been secured.

In order to cater for the needs of the layman, or of the specialist outside his own province as well as to satisfy the demands of the specialist on his own ground, each lengthy entry is introduced by means of a simple definition or a broad general description and this is then followed up with further detail and fuller development at a more advanced level. Cross references to related topics are indicated by printing key words in bold face type which denote separate entries in alphabetical position and afford access to a wealth of supplementary information.

The illustrations are generally good as well as plentiful though a few could be improved. A sectional drawing revealing the main constructional features of an electron microscope would be of greater scientific value than the photograph depicting its external form and that of its attractive operator.

Matters of topical interest receive appropriate attention. Seven pages are devoted to computers, six pages and one colour plate to guided missiles. Nuclear reactions and reactors, including a picture of the Calder Hall power station and a drawing of the USS Nautilus, occupy ten pages. Radioactivity, with an extensive list of radioactive nuclides of both natural and artificial origin, is dealt with in five pages. Television and a good account of colour television runs to six pages.

Entries relating to the major aspects of civil, electrical, chemical and mechanical engineering are numerous and informative. A vast amount of data is made readily available in the chemical section by presentation in tabular form. A few articles such as those on coupled circuits, electrical bridges and electron optics seem somewhat superficial in comparison with others, but the extent to which quite recent developments are covered is evidenced by such entries as maser, parity, zone melting, and so on. AID, coelocanth and Maxwell's thermodynamic relations were among the few items on which information was sought without success.

No biographical details of scientists are given though a list of Nobel Prize winners is included, and references to other sources of information are rarely provided. The article on flight lists significant events and historical flights in chronological order from 1485 to 1957. Medical information appears to be reasonably complete. The illustrations depicting a wide variety of living creatures would be made more generally useful by the insertion of an indication of scale alongside the illustration as is customary, for instance, in *Webster's Dictionary*.

The text seems commendably free from misprints, not more than a dozen quite minor ones being noted in a fairly thorough perusal.

The third edition of the Van Nostrand Scientific Encyclopaedia more than maintains the high standard set by its predecessors. Its primary purpose is to provide authoritative, comprehensive, up-to-date and readily located information on all branches of pure and applied science at levels that will satisfy the needs of students and experts alike. This it does admirably but the enquirer with more leisure will also find it a fascinating volume in which to browse in order to enlarge his knowledge.

NEW BOOKS

Machine Tools: What They Are and How They Work. By HERBERT D. HALL and HORACE E. LINSLEY. *Machinery Publishing Company Limited, National House*, 21 *West Street, Brighton*, 1. (52*s* 6*d*)

The book is intended as a broad introduction to machine tools for students in colleges, technical schools and machine shop training courses. It describes the purpose of machine tools, covering metal working processes, mass production, machine shop skills, fits, gauging and inspection, tooling up and work study. It also gives details of various types of machine tools including transfer machines and automation.

Automobile Electrical Equipment. By A. P. YOUNG and L. GRIFFITHS. *Iliffe and Sons Limited, Dorset House, Stamford Street, London, S.E.*1. (30*s*)

In the sixth edition of this well established manual describing the principles and components of automobile electrical systems, additional data is given on recent developments relating to *p-n* junction type rectifiers, electrical control in car transmission systems and impulse magnetisers, as well as a new chapter dealing with igniters for gas turbines.

The Metallurgy of Vanadium. By WILLIAM ROSTOKER. *John Wiley and Sons Incorporated*, 440 *Fourth Avenue, New York* 16, *N.Y., USA.* (8·50 *dol*); and *Chapman and Hall Limited*, 37 *Essex Street, London, W.C.*2. (68*s*)

The state of knowledge of the alloying and physical and mechanical properties of vanadium is far from complete. This book is described by the author as a progress report. It covers the extractive metallurgy of vanadium, its physical and mechanical properties; constitution of vanadium alloy systems and their properties; technology of vanadium, oxidation, corrosion and embrittlement; the metallography of vanadium and its alloys; and vanadium as an alloy addition.

Water in Mines and Mine Pumps. By JOHN SINCLAIR. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker Street, Kingsway, London, W.C.*2. (27*s* 6*d*)

The book is intended for undergraduates studying mining at Universities, and students of the Technical Colleges intending to take Higher National Certificates and Diplomas and Associate Membership of the Institution of Mining Engineers. It deals with the sources of water in mines and the resulting dangers; with pipes and fittings; reciprocating and centrifugal pumps for mines and finally with special purpose pumps. Test questions are provided at the end of each chapter and there is a brief bibliography.

Electric Furnaces. Edited by C. A. OTTO. *George Newnes Limited, Tower House, Southampton Street, London, W.C.*2. (35*s*)

The purpose of the book is to describe a wide range of applications of electrical heating practice. It contains 14 articles by different authors: on electrical phenomena; types of electrical furnaces; metal melting furnaces; indirect resistance furnaces; heat treatment of metals and alloys; induction heating; vacuum furnaces; salt bath furnaces; electric heat in the glass industry; vitreous enamelling furnaces; electrical heat in the pottery industry and in the plastics industry; control and measurement equipment; refractories and furnace linings.

On the Shelf

By Frank H. Smith

I was talking to a friend of mine the other day whom I had not seen for some time. He smiled wryly and said that the reason he was there was because "the boss" was on holiday and it was easier, therefore, to get to a main library (as opposed to a firm's library) to look things up. The boss, it seems, is one of those who thinks "we can work it out from our own resources" rather than allow a member of the technical staff to spend a day or two where everything is collected within reach. How *do* men get to the top if they do not realise the value of research before embarking on new projects? What type are they when they still feel that mature men are out to scrounge all the firm's time they can and cannot be trusted to do a day's work without teacher's supervision?

Much has been written and spoken, at various times, about the vast sums of money expended by the Ministry of Supply but only in the innermost circles is anything said about the difference in that department's abstracts and those published by the Water Pollution people, the Building Science people and the rest of the DSIR progeny. The latter are (or were as the case may be) properly printed and published while *Index Aeronauticus* is a comparatively poorly produced job with a duplicator look. Nevertheless it has proved an invaluable asset to the Industry—shoestring or no shoestring—and an idea of the ground still covered is conveyed by the "List of Journals Reviewed" which has been recently issued by the Ministry's Technical Information and Library Services (First Avenue House, High Holborn, W.C.1).

Radio Astronomers should have a half-crown's worth from the Library Association, Chaucer House, Malet Place, London, W.C.1, of the special subject list entitled "Radio Astronomy." Mr. F. R. Taylor, Librarian of the Technical Library of Manchester Public Libraries has contrived to whip up 204 references, Number 203 of which is from a Very Famous Journal on the subject of "WIRE telescope for radio Astronomy." Funnily enough ref. 204 has exactly the same title but from *Wireless World* and dated two months later. Scoop ! ! Any parent who still wonders what to do with his boy who left school last term may like to know that the RAF wants 700 boy entrants for the October entry. 15½-16½ on October 1, clever with his hands, keen on engineering?

I think most of my readers (both of them) know that I am not a member of ENGINEERING's staff (I'd have got the sack long ago if I were) so that it will not be a case of trumpet blowing when I say that there is ample evidence that the recent series of articles by E. P. Ward on the American way of life was extremely well received. In fact, the usual letters that come in asking how much longer we have to put up with Smith invariably had a postscript to the effect give us more Ward. Be that as it may, you will like to know that it is now possible to buy the whole series of articles in booklet form for eight shillings. One could buy many worse and more useless things to send as Christmas presents to business associates—particularly those in America who should be delighted to receive an independent assessment from their poor but struggling relations. The booklet, measuring about 13 in by 9 in, is called "Talking to Americans; What they are Thinking and Where it Leads." Far be it from me to suggest that it is to the Presidential golf-course. Anyway—remember, the price is 8*s*.

Last week even the most unobservant of my readers must have wondered what I meant in my last paragraph by a "bungle of faggots". This had no reference to a culinary confusion but should have read "bundle of faggots"—a rather subtle (I thought) reference to the Roman fasces or an old proverb which implies that a lot of sticks bound together are stronger than several sticks one at a time. Is *that* clear?

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CARDIFF
"Silicones in the Electrical Industry," by J. Davies. South Wales Branch. Angel Hotel, Cardiff. Tues., 14 Oct., 7.30 p.m.
WOLVERHAMPTON
"Applications of Electricity to Mining," by G. W. Hall. Wolverhampton Branch. Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton. Wed., 15 Oct., 7.45 p.m.

British Institute of Management

LONDON
"Computers: Top Management Appraisal," by John Diebold. Connaught Rooms, Great Queen Street, W.C.2. One-day conference, Tues., 21 Oct., commencing at 10 a.m.

British Institution of Radio Engineers

CARDIFF
"Principles of Transistor Circuitry," by B. R. A. Bettridge. South Wales Section. Cardiff College of Advanced Technology, Cardiff. Wed., 15 Oct., 6.30 p.m.
LIVERPOOL
"Manufacture of High-Frequency Surface Barrier Transistors," by P. A. Charman. Merseyside Section. University Club, Liverpool. Wed., 15 Oct., 7 p.m.

Chemical Engineering Group

LONDON
"Titanium and Its Alloys as Materials of Construction for Chemical Plant," by Dr. K. W. J. Bowen. Society of Chemical Industry, 14 Belgrave Square, S.W.1. Tues., 14 Oct., 6 p.m.

Chemical Society

LONDON
Centenary Lecture: "Spectra of Free Radicals," by Dr. G. Herzberg. Imperial College of Science and Technology, South Kensington, S.W.7. Thurs., 16 Oct., 7.30 p.m.

Diesel Engineers and Users Association

LONDON
Annual General Meeting. "Automatic Control of Engine Driven Plants," by E. R. Hill. Institute of Marine Engineers, 76 Mark Lane, E.C.3. Thurs., 16 Oct., 2 p.m.

Illuminating Engineering Society

LONDON
Presidential Address on "Light and Life," by C. C. Smith. Royal Institution, Albemarle Street, W.1. Tues., 14 Oct., 6 p.m.
SHEFFIELD
Chairman's Address, by K. Marshall. Sheffield Centre. Grand Hotel, Sheffield. Mon., 13 Oct., 6.30 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Giant Earth Mover Tyres," by W. Wortley (with film). Birmingham Mobile Plant Discussion Group. Imperial Hotel, Temple Street, Birmingham. Fri., 17 Oct., 7.30 p.m.
BLACKBURN
"The Work of the Baths Engineer," by T. Anderson. White Bull Hotel, Blackburn. Thurs., 16 Oct., 7.30 p.m.
MANCHESTER
"Industrial Electronics," by Commander V. J. Copley-May. Manchester Branch. Engineers' Club, Albert Square, Manchester. Tues., 14 Oct., 7.15 p.m.
ROCHESTER
"Ultrasonics in Industry," by C. B. Abel-Harry. Kent Branch. King's Head Hotel, High Street, Rochester. Wed., 15 Oct., 7 p.m.

Institute of Marine Engineers

LONDON
"An Investigation into the Optimum Machinery Installation for a Large Steam Turbine Tanker," by Commander A. D. Bonny. Tues., 14 Oct., 5.30 p.m.*

Institute of Road Transport Engineers

LONDON
Annual General Meeting. "Summer and Winter Protection Against Corrosion in Engine Water-Cooling Systems," by L. J. Cotton. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Thurs., 16 Oct., 6.30 p.m.*
BIRMINGHAM
Discussion on "Road Safety." Midlands Centre. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Tues., 14 Oct., 7.15 p.m.
MANCHESTER
"Brakes and Brake Linings," by Dr. N. Carpenter. East Regional Centre. Houldsworth Hall, 90 Deansgate, Manchester. Mon., 13 Oct., 7.30 p.m.
PLYMOUTH
"Selection and Use of Fuels and Lubricants for Road Transport," by R. D. Owen. South Western Group. Duke of Cornwall Hotel, Plymouth. Tues., 14 Oct., 7.30 p.m.

Institution of Chemical Engineers

DERBY
"Flow Patterns in the Hydraulic Cyclone and Their Interpretation in Terms of Performance," by D. Bradley and D. J. Pulling. Midlands Branch. Technical College, Derby. Sat., 18 Oct., 3 p.m.
MANCHESTER
"Mass Transfer and Diffusion Phenomena in a Rotary Concentric-Cylinder Distillation Column," by N. Macleod. North Western Branch. Chemical Engineering Building, College of Science and Technology, Jackson Street, Manchester. Tues., 14 Oct., 6.30 p.m.

Institution of Civil Engineers

LONDON
"The Garry and Moriston Hydro-Electric Schemes," by C. M. Roberts, E. B. Wilson, J. H. Thornton and Henry Headland. Tues., 14 Oct., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "The Rationalisation of the Avenues of Higher Education for Electrical Engineers," opened by the President, S. E. Goodall. Mon., 13 Oct., 5.30 p.m.*
Chairman's Address on "The Scope of the Measurement and Control Section," by J. K. Webb. Measurement and Control Section. Tues., 14 Oct., 5.30 p.m.*
Chairman's Address on "Installation Engineering," by R. A. Marryat. Utilization Section. Thurs., 16 Oct., 5.30 p.m.*
Chairman's Address on "Electrical Power Generation and Its Future in Southern England," by J. F. Outram. Graduate and Student Section. Wed., 15 Oct., 6.30 p.m.*
BELFAST
Chairman's Address on "The Insulator Surface," by Dr. D. S. McIlhagger. Northern Ireland Centre. Queen's University, Belfast. Tues., 14 Oct., 6.30 p.m.
BRISTOL
Chairman's Address, by R. W. Steel. Western Centre. Electricity House, Carlton Avenue, Bristol. Mon., 13 Oct., 6 p.m.*
HULL
"A Test Bed for Direct-Current Machines and Control Gear," by J. Holgate and E. Rawnsley. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., 16 Oct., 6.30 p.m.
NEWCASTLE UPON TYNE
Chairman's Address, by A. T. Crawford. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 13 Oct., 6.15 p.m.
PORTSMOUTH
"Reheat Practice in Power Stations," by F. H. S. Brown and G. W. H. Dore. Southern Centre. Joint meeting with the Institution of Mechanical Engineers (Southern Branch). College of Technology, Anglesea Road, Portsmouth. Wed., 15 Oct., 6.30 p.m.*

Institution of Engineering Designers

NEWCASTLE UPON TYNE
"Design of Water-Turbine-Driven Alternating-Current Generators," by G. R. Small. North East Branch. Northern Architectural Association's hall, 6 Higham Place, Newcastle upon Tyne. Mon., 13 Oct., 7.15 p.m.

Institution of Heating and Ventilating Engineers

BIRMINGHAM
"Air Conditioning in Hospitals and Some Related Aspects of Lighting," by J. P. Sandison. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Tues., 14 Oct., 6.30 p.m.
LEEDS
"Packaged Boilers," by R. D. Northcote. Yorkshire Branch. Powolnys Restaurant, Leeds. Wed., 15 Oct., 7.30 p.m.
MANCHESTER
"Survey of Methods of Pressurisation for Medium and High-Pressure Hot-Water Systems," by J. R. Kell. Manchester Branch. Engineers' Club, Albert Square, Manchester. Fri., 17 Oct., 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"The Mechanics of the Train in the Service of Railway Operation," by S. O. Ell. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Wed., 15 Oct., 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Presidential Address, by Sir R. Owen Jones. Fri., 17 Oct., 6 p.m.*
BIRMINGHAM
"Electronics in the Service of Mechanical Engineers," by F. S. Coles. Midland Branch. James Watt Memorial Institute, Great Charles Street, Birmingham. Thurs., 16 Oct., 6 p.m.*
HULL
"Modern Trends in Waterworks Pumping Machinery," by T. Irvine Hudson. Yorkshire Branch. Royal Station Hotel, Hull. Wed., 15 Oct., 7.30 p.m.
SLOUGH
Technical Film Evening. Eastern Branch. Good Companions' Hotel, Slough. Tues., 14 Oct., 7.30 p.m.

Institution of Mining and Metallurgy

LONDON
"Sinking No. 2 Shaft, Harmony Gold Mining Co. Ltd., Orange Free State," by S. C. Newman; and "The Micropanner: An Apparatus for the Gravity Concentration of Small Quantities of Materials," by L. D. Muller. Geological Society, Burlington House, Piccadilly, W.1. Thurs., 16 Oct., 5 p.m.*

Institution of Production Engineers

BIRMINGHAM
"Productivity, the Production Engineer, and the European Common Market," by Michael Halls. Birmingham Section. James Watt Memorial Institute, Great Charles Street, Birmingham. Wed., 15 Oct., 7.30 p.m.
BRISTOL
"Productivity in the European Common Market," by Lieut.-General Sir Thomas Hutton. Western Section. Large Lecture Theatre, The University, Bristol. Wed., 15 Oct., 7.30 p.m.
COLCHESTER
"Building Merchant Ships in a Modern Shipyard," by J. Leather. Ipswich and Colchester Section. Britannia Works canteen, Davey, Paxman and Co. Ltd., Colchester. Fri., 17 Oct., 7.30 p.m.
HALIFAX
"We Build the Jig Mill," by R. C. Fenton. Halifax and Huddersfield Section. Percival Whitney Technical College, Francis Street, Halifax. Wed., 15 Oct., 7.30 p.m.
NEWCASTLE UPON TYNE
"Sintered Oxides as Cutting Tools," by H. Eckersley. Newcastle upon Tyne Section. Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne. Mon., 13 Oct., 7 p.m.
PRESTON
"A New Approach to Production Control," by J. L. Burbidge. Preston Section. Harris College of Further Education, Corporation Street, Preston. Wed., 15 Oct., 7.30 p.m.
WOLVERHAMPTON
Open Discussion on "Recording and Accounting." Wolverhampton Senior and Graduate Sections. Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton. Wed., 15 Oct., 7 p.m.

Institution of Public Health Engineers

LONDON
"Extremes of Rainfall," by A. Bleasdale. Caxton Hall, off Victoria Street, S.W.1. Thurs., 16 Oct., 6 p.m.

Institution of Structural Engineers

LONDON
"Design of Cities," by Johnson Marshall. London Graduates' and Students' Section. Tues., 14 Oct., 6.30 p.m.*
GLASGOW
Chairman's Address, by W. Heigh. Scottish Branch. 39 Elmbank Crescent, Glasgow, C.2. Mon., 13 Oct., 7 p.m.
LEEDS
Chairman's Address, by Professor R. H. Evans. Yorkshire Branch. Metropole Hotel, Leeds. Wed., 15 Oct., 6.30 p.m.
SHEFFIELD
Chairman's Address, by Professor R. H. Evans. Yorkshir Branch. Royal Victoria Hotel, Sheffield. Thurs., 16 Oct. 6.30 p.m.

Junior Institution of Engineers

LONDON
"Radio Measurements on the Russian Earth Satellites," by John Heywood. Fri., 17 Oct., 7 p.m.*

Reinforced Concrete Association

LONDON
"The Architectural Expression of Structural Concrete," by W. A. Gibbon. 11 Upper Belgrave Street, S.W.1. Wed., 15 Oct., 6 p.m.*
BIRMINGHAM
Film Evening. Midland Counties Branch. Birmingham and Midland Institute, Paradise Street, Birmingham. Tues., 14 Oct., 6 p.m.*

Royal Meteorological Society

LONDON
Various short papers. Wed., 15 Oct., 5 p.m.*

Royal Statistical Society

LIVERPOOL
"Operational Research in Industry," by Dr. K. D. Tocher. Merseyside Industrial Applications Group. Royal Institution, Colquitt Street, Liverpool. Tues., 14 Oct., 7 p.m.*

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Atmospheric Pollution in the Iron and Steel Industry," by J. H. Flux and F. A. Gray. Mon., 20 Oct., 7.30 p.m.

Society of Instrument Technology

LONDON
"A Simple Data Read-Out System," by G. P. Tonkin and J. B. Bownas. Data Processing Section. Manson House, Portland Place, S.W.1. Mon., 20 Oct., 6 p.m.*
LEICESTER
"Semi-Conductors and Their Applications," by G. M. Ettinger. East Midland Section. College of Technology and Commerce, The Newarke, Leicester. Thurs., 16 Oct., 7 p.m.*
MANCHESTER
"Accuracy in the Production of Modern Instruments," by H. Matthews. Manchester Section. Central Library, St. Peter's Square, Manchester 1. Tues., 14 Oct., 6.30 p.m.
MIDDLESBROUGH
"A Quantitative Approach to Level Control", by R. Jackson. Tees-Side Section. Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough. Wed., 15 Oct., 7.30 p.m.
NEWCASTLE UPON TYNE
"The Progress of Temperature Measurement in Industry," by R. Postle. Newcastle Section. Stephenson Buildings, King's College, Newcastle upon Tyne. Wed., 15 Oct., 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
Presidential Address, by Dr. H. Harris. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Fri., 17 Oct., 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4. (HOLborn 3456.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Chemical Engineering Group, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House Piccadilly, London, W.1. (REGent 0675.)
Diesel Engineers and Users Association, 18 London Street, London, E.C.3. (ROYal 2393.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, London, S.W.1. (SLOane 0469.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria Street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland Place, London, W.1. (LANgham 3802.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's Square, Sheffield 1. (Sheffield 24071.)
Society of Instrument Technology, 20 Queen Anne Street London, W.1. (LANgham 4251.)
West of Scotland Iron and Steel Institute, 39 Elmbank Crescent Glasgow, C.2. (Central 5181.)

Design

LOSSES IN SMALL REFRIGERATOR COMPRESSORS

*Operating Efficiency of Domestic Size Units Measured**

By S. Forbes Pearson, B.SC., A.R.C.S.T., PH.D., A.M.INST.R.†

In recent years considerable improvement has been made to the heart of the mechanical refrigeration system, the compressor itself. Pre-war compressors were, in general, belt driven from a separate electric motor and relatively low speeds were employed. The post-war domestic compressor is directly driven by a squirrel-cage motor on the crankshaft and the whole assembly is sealed within a steel housing. This type of construction is of considerable advantage in reducing the amount of trouble caused by refrigerant leaks. The steel housing also acts as a very efficient silencer making modern compressors almost inaudible.

The neatness of the single-shaft arrangement coupled with the reduction in cylinder dimensions obtained by increasing the compressor speed has produced a dramatic reduction in the space required for the compressor and its motor. This can be observed in Fig. 1 which shows compressor units of comparable power. Sealed units have not yet been accepted as suitable for larger refrigeration plants, but even here an increasing use of V- and W-configurations running at high speeds has produced some very compact designs.

However, the rapid development of high-speed compressors has introduced new problems while solving others. It is a surprising fact that the modern compressor is rather less efficient than its cumbersome predecessors.[1] If this were merely a reflection of the unwanted heat trapped in the refrigeration system by the sealed electric motor it would not be surprising but, in fact, there has been a reduction in volumetric efficiency which is noticeable not only in the small machines but also in the larger ones that do not contain an integral motor. The reduction in efficiency is not due directly to the higher speeds employed to-day but can be traced, in part, to the type of valves used in conjunction with high-speed machines.

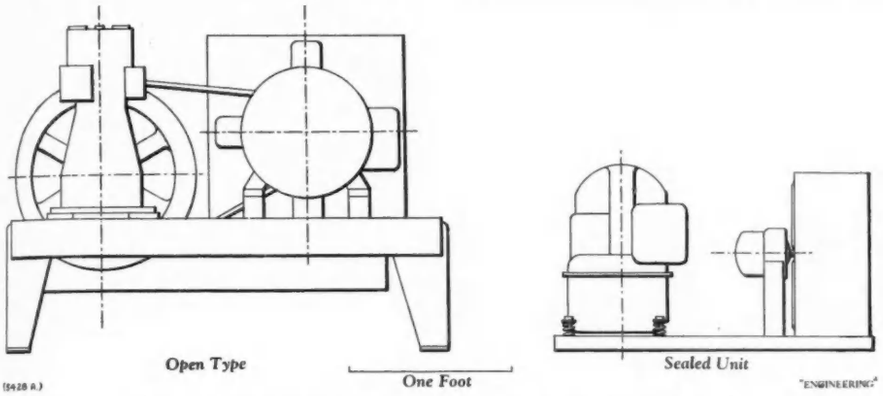


Fig. 1 Comparison of size of two types of 1 h.p. condensing units.

The volumetric efficiency of a compressor is defined as

$$\frac{\text{Volume of vapour, at suction conditions, pumped per unit time}}{\text{Volume swept out by piston per unit time.}}$$

Since the war, a considerable amount of research has been done at the Royal College of Science and Technology, Glasgow, with the object of improving compressor efficiency. It was soon discovered that overall volumetric efficiency does not give a clear indication of the relative importance of the various losses affecting a compressor. In order to provide data for rational design and development it is necessary to separate and measure the various losses associated with these machines.

The main losses affecting volumetric efficiency are caused by:

1. Heat transfer between fluid and cylinder.
2. Re-expansion of clearance volume vapour.
3. Valve throttling.
4. Blowback past the valves while closing.
5. Leakage past the piston.
6. Leakage due to imperfect seating of the valves.

Careful investigations into valve throttling losses,[2] heat transfer losses[3] and piston leakage

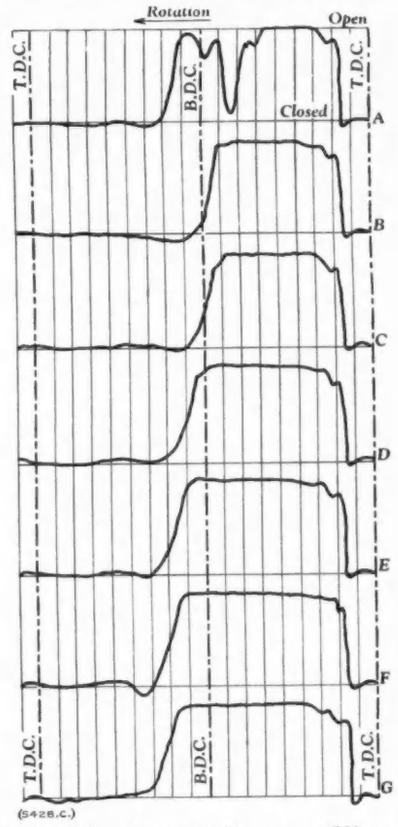


Fig. 3 Valve movement diagrams at 750 r.p.m. See Fig. 4.

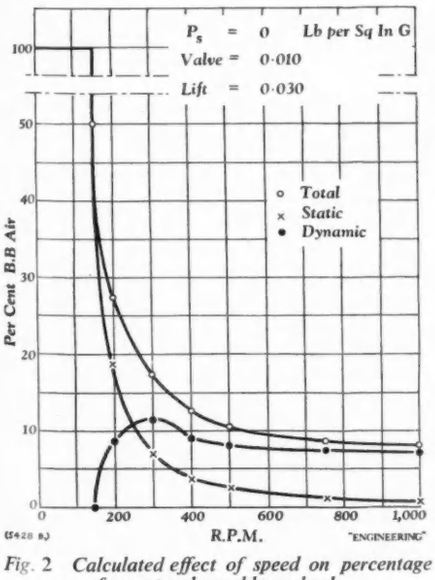


Fig. 2 Calculated effect of speed on percentage of swept volume blown back.

NOMENCLATURE

r_v	=	radius of valve disc
r_t	=	radius of valve port
r_p	=	radius of piston
R	=	ratio $\frac{r_v}{r_t}$
V_v	=	gas velocity parallel to valve plate at edge of valve disc
V_t	=	gas velocity parallel to valve plate at port circumference
V_p	=	instantaneous piston velocity
V_m	=	maximum piston velocity
P_c	=	pressure in cylinder
w	=	gas density
W	=	weight of valve
l	=	distance between valve and valve plate
t	=	acceleration due to gravity
θ	=	time
g	=	angle between crank position and bottom dead centre

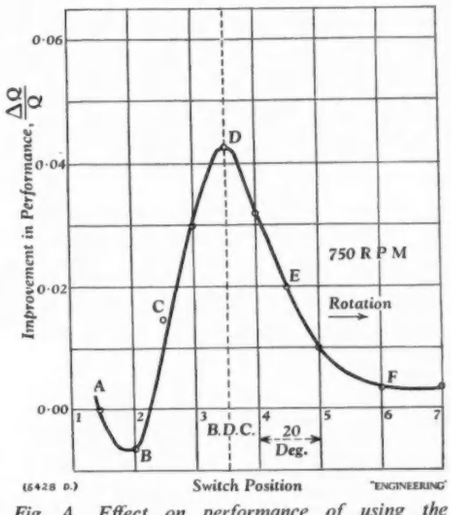


Fig. 4 Effect on performance of using the different valve motions shown in Fig. 3.

* Paper read before Section G, British Association, in Glasgow, on Monday, 1 September, 1958.

† Formerly of the Royal Technical College, Glasgow, where the work described was undertaken, and now of the Torry Research Station, DSIR, Aberdeen.

were carried out at the Royal College and it was concluded that losses other than those measured were also significant. Re-expansion losses had also been measured and, from the results of static tests, leakage due to imperfect seating of valves could be assumed to be slight. Attention was therefore directed towards the loss caused by vapour being blown back past the suction valve before the latter closed at the start of the compression stroke.

The suction valve of small high-speed compressors is usually made of a metal reed about 0·010 in thick. The reed is loosely located on pins so that it covers the suction port. During the suction stroke vapour flows into the cylinder past the valve which remains about 0·030 in from its seat. On the compression stroke the suction valve is forced on to its seat by the pressure in the cylinder. The valve is not held in place by springs and has no spring stiffness of its own when in the closed position. It can easily be seen that this type of suction valve must cause some blowback before it closes.

Preliminary investigations indicated that blowback of the order of 5 to 10 per cent of the total induced volume might take place and it was decided to attempt to measure this loss.

THEORY

The theoretical case of a disc-shaped suction valve undergoing reversed radial flow without pressure recovery at the throat was considered initially. The force on the valve was derived as

$$\frac{\pi w V_t^2 r_t^2}{2g} [1 + 2 \log_e R]$$

The critical piston velocity required to initiate closure of the valve is given by

$$V_p = \frac{2l}{r_p^2} \sqrt{\frac{2gW}{\pi w (1 + 2 \log_e R)}}$$

If the compressor is not running fast enough to produce this velocity, the valve will not close and the volumetric efficiency will be zero. Even if the critical velocity is reached, blowback will also occur while the valve is closing. The equation governing the motion of the valve during this period was found to be

$$\frac{d^2 l}{dt^2} = \frac{\pi}{8} \frac{w r_p^4}{W} [1 + 2 \log_e R] V_m^2 \frac{\sin^2 \theta}{l^2} - g$$

For convenience, the blowback was separated into two parts, the "static loss," which was assumed to occur before the critical velocity had been reached, and the "dynamic loss" which occurred during the closing process.

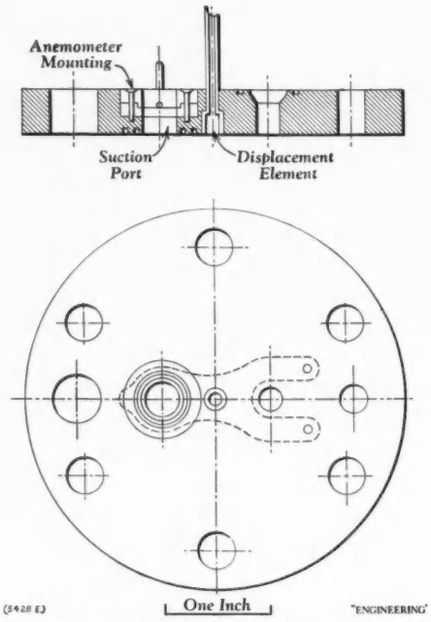


Fig. 5 Compressor valve plate details.

The theoretical solutions were modified to apply to a practical type of valve reed, which is shaped more like a beam than a disc, and the amount of blowback under various conditions was calculated. The static loss was obtained directly but the dynamic loss had to be obtained by a re-iterative solution of the differential equation of valve closure. The calculated effect of speed on the blowback past the valve of a typical small compressor is shown in Fig. 2.

PRELIMINARY EXPERIMENTS

Unfortunately it is easier to theorise about blowback than to measure it.

Preliminary attempts to assess the amount of blowback taking place depended on modifying the valve behaviour in such a way that blowback was eliminated and then on measuring the resulting improvements in performance. The valve was induced to close under the action of an electromagnet which could be switched on at a given instant during each cycle of a test. The effect of the magnet is illustrated by the valve movement diagrams of Fig. 3. Diagram A, Fig. 3, shows the valve being closed at an early stage by the magnet and then being re-opened by the oncoming vapour. Diagrams B to F show the effect of firing the magnet at progressively later stages in the cycle. Diagram G is the natural movement of the valve without magnetic action. The compressor used was an $\frac{1}{8}$ h.p. open-type machine and the valve-movement diagrams were obtained from a capacitative pick-up bonded into the valve plate. The valve reed formed the earthed plate of the varying capacitor.

The effect on performance of the various types of valve motion shown in Fig. 3 is illustrated in Fig. 4. The position at which switching on the magnet produces the greatest improvement in performance is easily seen. Switching on the magnet after this position does not eliminate all the blowback. Switching on the magnet before the optimum point, produces increased throttling losses which may even result in a reduction in performance, as at B. The change in performance was measured by running the compressor with the magnet in operation till conditions became steady and noting the head produced by the discharge vapours flowing through a standard orifice. The magnet was switched off and the change in manometer reading noted.

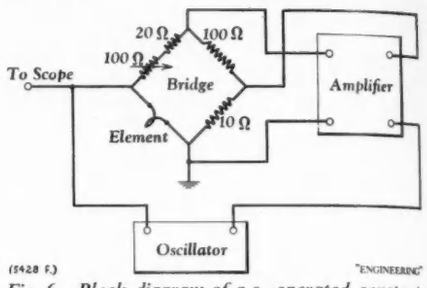
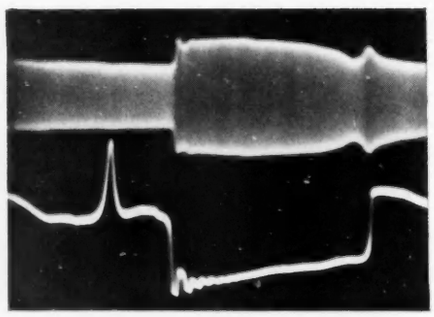


Fig. 6 Block diagram of a.c. operated constant-temperature hot-wire anemometer.

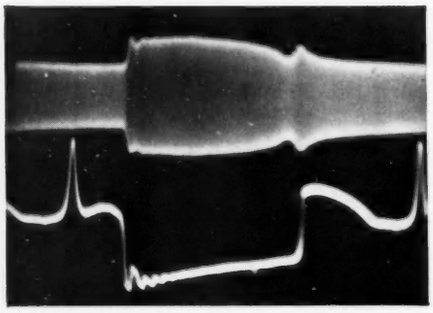
It is easily shown that the percentage change in compressor performance is equal to half the percentage change in manometer head. Though the electromagnetic method gave interesting results which were readily reproducible, it proved impossible to separate the effects of valve throttling and blowback by this method. It was decided that unequivocable blowback results could not be produced without a direct method of measuring the instantaneous velocity in the valve port.

DIRECT VELOCITY MEASUREMENTS

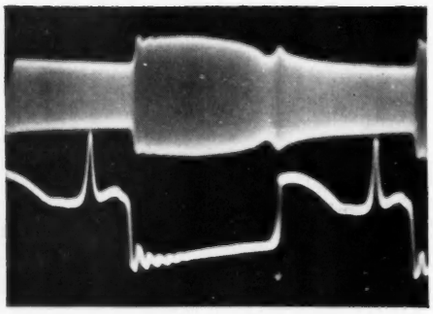
The instrument chosen to make direct-velocity measurements in the suction port of the compressor was a constant-temperature hot-wire anemometer. An insulated bush was set into the upper part of the suction port and the sensitive element of the anemometer, a tungsten wire of 0·0005 in diameter, stretched right across it. The arrangement can be seen in Fig. 5. The tungsten wire forms part of a resistive bridge illustrated in Fig. 6. The bridge was supplied with alternating current from a 5 kc per sec oscillator in series with the output of an amplifier. The input terminals of the amplifier were connected across the balance points of the bridge. The purpose of the amplifier is to detect slight unbalances in the bridge and to feed power into the system in such a way that the unbalance is minimised. When the gas velocity past the wire increases, carrying away a greater quantity of heat, the amplifier feeds additional power into the system to bring the wire back to its original resistance, thus maintaining it at a temperature which is very nearly constant. Similarly, reduced velocity past the wire results



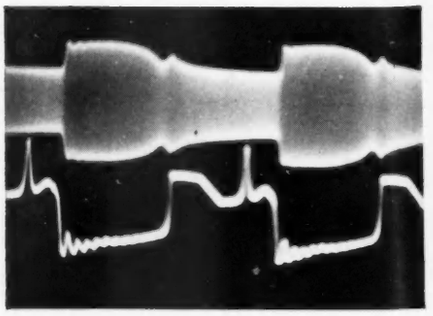
500 r.p.m.



600 r.p.m.



750 r.p.m.



1,000 r.p.m.

Fig. 7 Anemometer and valve diagrams taken from tests at different speeds using Freon. The valve had a thickness of 0·010 in and a lift of 0·030 in.

in the amplifier opposing the output from the oscillator and decreasing the power supplied to the wire. The velocity of the gas is a known function of the power supplied to keep the bridge balanced. The electronic feedback is introduced so that rapid changes in velocity can be indicated, the responsibility for following velocity fluctuations being transferred from the relatively sluggish wire to the rapidly responding electronic equipment.[4] Direct current amplifiers are normally used in constant-temperature anemometers but it was considered that the present application justified the development of the a.c. technique which has important advantages provided the velocity does not fluctuate too rapidly. The 5 kc per sec carrier wave chosen was above the 200th harmonic of the fundamental velocity fluctuation and thus appeared perfectly suitable for indicating instantaneous mean-velocity fluctuations.

The anemometer was applied to two small compressors, the $\frac{1}{6}$ h.p. open-type machine already mentioned and an $\frac{1}{8}$ h.p. sealed machine

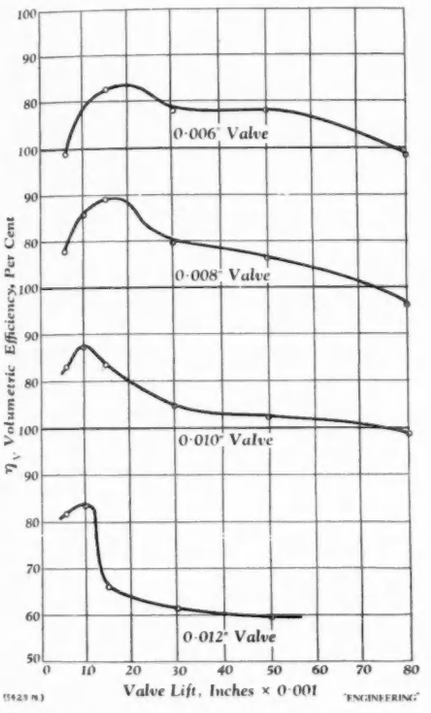


Fig 9 Effect of valve lift on volumetric efficiency at 500 r.p.m.

of American design. Equipment to indicate the motion of the suction valve was also included in each compressor. The sealed unit, being driven by an a.c. motor, ran at more or less constant speed but the open machine was directly coupled to a d.c. motor and could be run at speeds of up to 1,500 r.p.m. Because of its greater flexibility the open-type unit was chosen to study the influence of speed, valve weight, valve lift and fluid density on blowback. The tests carried out on the sealed unit were mainly concerned with the effects of pressure ratio and vapour density. Freon 12 and air were used as the working fluids. Because of the large numbers of tests involved the performance of the compressors was generally measured by means of calibrated orifice plates. The use of a full Freon condensing cycle, employing heat balance techniques to measure the refrigerant flow, involved tests of about 8 hours' duration which was impracticable. In general, the rate of pumping was measured by means of the orifice and the anemometer and valve-movement diagrams were photographed from a twin-beam oscilloscope. The anemometer diagram, the width of which is a function of velocity, was linearised according to King's equation[5] so that a trace directly proportional to velocity was

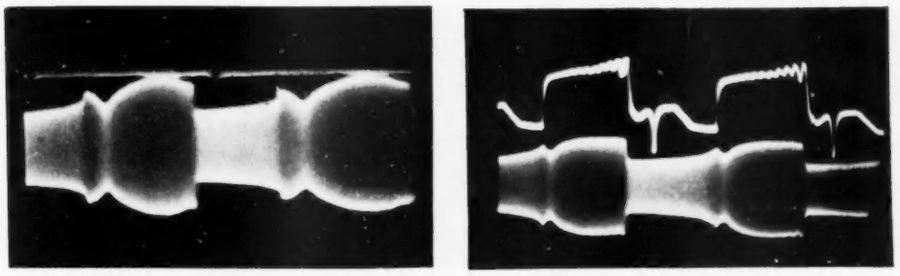


Fig. 8 Anemometer diagrams; effect of working fluid.

produced. The areas under the velocity diagram are proportional to flow quantities and thus a scale can be found, after allowance has been made for the effect of blowback and leakage past the piston, by comparison with the orifice readings.

It is an indication of the surprising consistency of the valve behaviour that anemometer and valve-movement diagrams involving rapid accelerations and sometimes violent oscillation could be photographed from the oscilloscope screen using exposures of up to three seconds. The types of record obtained by this equipment are shown in Fig. 7. The width of the upper trace is a function of gas velocity in the suction port. The abrupt rise in velocity caused by the opening

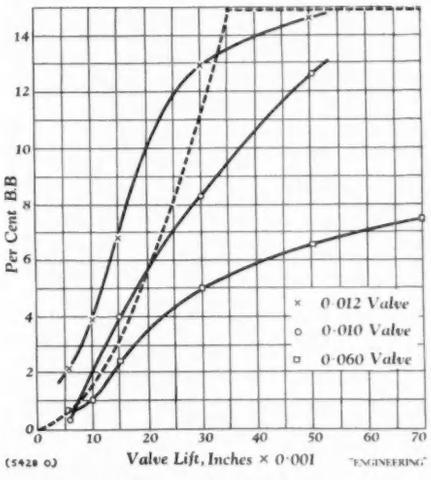


Fig. 10 Effect of valve lift on percentage of induced volume blown back at 500 r.p.m.

of the valve can be clearly seen, as can be the second velocity peak caused by a slight blowback past the valve after bottom dead centre. The lower trace is an indication of valve movement with a phase marker introduced to show top dead centre. The first peak is the marker and this is followed by the abrupt step indicating the opening of the valve leading to a transient oscillation which shows a tendency to become more serious at higher speeds. The valve closure is seen to occur some distance after bottom dead centre. Fig. 8 shows the effect of fluid density on blowback, the records being taken from the same compressor pumping air and Freon under otherwise similar conditions.

EXPERIMENTAL RESULTS

The anemometer was used in several series of tests designed to show the effect of compressor speed, fluid density, valve weight and permitted lift on blowback.

Fig. 9 shows how the lift of various valve arrangements affected the overall volumetric efficiency of the small refrigeration compressor. Air was the working fluid and the compressor was run somewhat below its designed speed in order to accentuate blowback effects. It can be seen that there is a marked increase in volumetric efficiency at lifts below 0·020 in and that this increase is more pronounced in the case of the heavier valves. This type of behaviour is consistent with the presence of blowback at the normal operating lift of 0·030 in.

Fig. 10 shows the effect of valve lift on blowback as measured by the anemometer for various thicknesses of valve reed. The broken line is a theoretical curve derived for a 0·010 in valve reed operating at 500 cycles per min. The shape of the theoretical curve is similar to the experimental curves relating to the stiffer valves, but is not such a good approximation in the case of light flexible valves. This is to be expected, as bending of the valve reed was not considered in the theoretical computation of blowback.

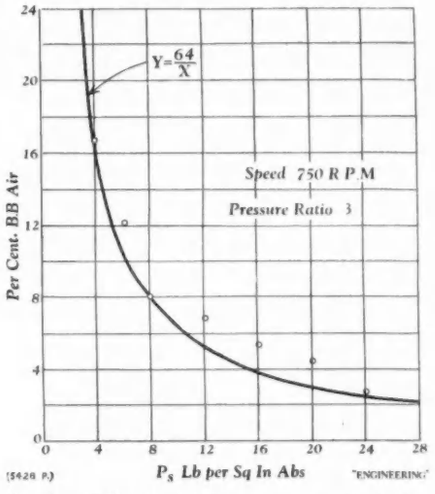


Fig. 11 Effect of suction pressure on percentage of induced volume blown back at 750 r.p.m. and a compression ratio of 3.

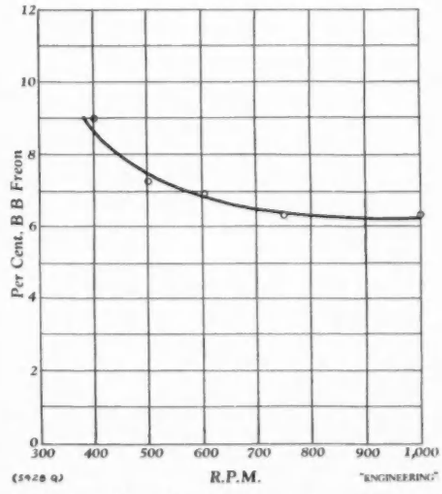


Fig. 12 Effect of speed on percentage of induced volume blown back, with Freon as working medium.

Continuing **Design**

The effect of valve lift on blowback was also examined at other speeds but the results are not shown here because they are affected in some cases by self-excited oscillation of the valve reed.

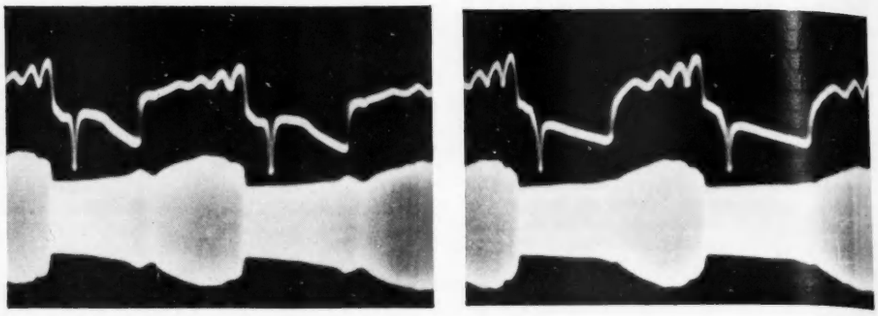
Fig. 11 shows the effect of suction pressure, i.e., fluid density, on blowback. The results indicate that unclamped suction reeds are not suitable for use with low pressures or light gases. At extremely low pressures the suction valve appeared to cease to function in any useful way. Blowback was very large and the anemometer also detected considerable leakage past the closed suction reed which was not seating properly owing to lack of pressure force. The illustration indicates that blowback is more or less inversely proportional to the density of the suction vapour.

The effect of speed on blowback is illustrated in Fig. 12 which relates to a series of tests using Freon 12. The dependence of blowback on speed is seen to be similar to that deduced from theoretical considerations.

Fig. 13 illustrates the effect which oscillation of the valve reed can have on blowback. Owing to the timing of the oscillation the amount of blowback is increased at 950 r.p.m., but is reduced almost to vanishing point at 1,000 r.p.m.

The occurrence of oscillation is difficult to predict as it is very much affected by the presence of oil on the valve and at its supports. The normal effect of oscillation is to reduce the amount of blowback but, by a freak of timing, blowback can be produced where it would otherwise have been absent.

It is interesting to note that the oscillation recorded in Fig. 13 suggests that the valve was vibrating as a cantilever when the record was made. The normal frequency of oscillation, as a simply supported beam, is about twice that shown here. It is consistent with the dimensions of the cylinder head that the valve should vibrate as a cantilever at high lifts. The oscillation recorded here is relatively slight but on many occasions, particularly when the valve was clamped in place, very violent oscillations were set up. Violent oscillations absorbed up to 10 per cent additional power from the driving motor—but generally had little effect on the overall volumetric efficiency because the additional throttling losses produced were usually balanced by the elimination of blowback. It was quite common for the volumetric efficiency of the open type compressor to improve when an oscillation of the valve became established. This indicates the dangers of drawing conclusions about processes within such compressors by considerations of volumetric efficiency alone.



950 r.p.m. 1000 r.p.m.

Fig. 13 Anemometer and valve diagrams from compressor A, using a 0·010 in thick valve and a lift of 0·070 in. The working fluid was air and the diagrams show the effect of oscillation.

CONCLUSIONS

The preliminary tests carried out using an electromagnet to modify the valve behaviour indicated that blowback of the order of 5 to 10 per cent was taking place.

An instrument which was able to make direct measurements of blowback was constructed and applied under various conditions. It was found that the instrument was suitable for blowback measurements even on very small compressors.

It was also found that the records produced by the instrument could be used to measure the losses caused by re-expansion of clearance volume vapour and by underpressure at bottom dead centre. Under certain conditions it was also possible to observe the effects of leakage past the closed suction reed, but in general this was too small to be noticed.

The variation of blowback with valve weight, valve lift, fluid density and compressor speed was examined and found to be in fair agreement with the theory previously outlined.

It was decided that unclamped suction reeds were not suitable for use at low speeds or when pumping lightweight vapours. The best conditions for their use appear to be a combination of lightweight valve, low lift, large port diameter and high speed. Clamped suction reeds generally reduced the blowback but proved very liable to oscillate under the action of the incoming vapour. It was considered that the advantages of clamping might be enjoyed without oscillation by the use of two thin reeds clamped together at the " hinge " end. The damping produced by the oil film between the valves would prevent oscillation.

There is no reason why relatively inexpensive anemometers of the type described in this paper should not be employed in the inlet and exhaust systems of engines and compressors running at high speeds. The great advantage of the system from the practical man's point of view is that it gives a direct picture of the velocity changes and fluctuations taking place at the point being studied. Thus the effect of slight changes of design and construction can be studied with ease and a rapid process of development undertaken.

Acknowledgment.—The experiments on which this paper is based were performed in the Engineering Laboratories of the Royal College of Science and Technology. The author wishes to thank the College authorities for the facilities provided and the Professors and staff of the engineering departments for their help and advice.

The author would also like to thank L. Sterne and Company Limited, who provided the compressors and who were very generous in their assistance.

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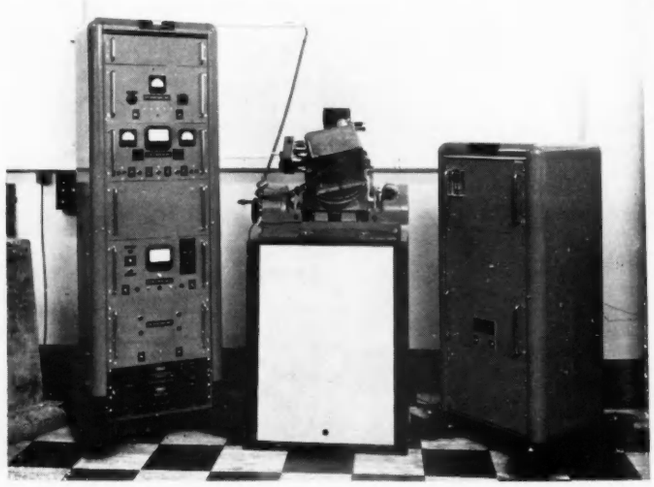
EVALUATING GYRO WANDER

In connection with guided weapons research, A. V. Roe and Company Limited, Greengate, Middleton, Manchester, have developed an apparatus for the evaluation of low wander-rate gyroscopes. The gyroscope under test is mounted on an accurately aligned table which, by means of a servo system, follows the gyro movement. A measurement of the table rate is thus a measure of the gyro wander rate, plus any component of earth rate which may be present. The table is fitted with a digital optical pick-off arranged to give output pulses for very small angular movements. The pulses are used to trigger a time counter fed from a highly stabilised frequency source, the resulting count being sampled at regular intervals and the information automatically read out and displayed on a printing mechanism.



The gyroscope under test is mounted on a table which follows the gyro movement by means of a servo system.

Production

BULK HANDLING IN THE PRODUCTION CYCLE

Powdered raw material travels to the works of Aspro-Nicholas Limited in "Tote" bins. There it is unloaded by a fork-lift truck.

HANDLING of components in bulk by means of pallets and fork-lift trucks is a popular and convenient arrangement both for internal factory transport and for movement of goods between factories at any distance apart. This system of materials handling is equally applicable to powders, granulated materials or liquids, and standardised equipment is made for the purpose by Pressoturn Limited, Leamington Spa, Warwickshire. Known as the "Tote" system, the handling equipment is basically simple, consisting of a container or bin, together with a discharging unit and a filling unit for use under certain conditions. The Tote system is infinitely flexible, and can provide storage capacity as required.

Three standard bins form the basis of the system. All are made to the same design in heavy gauge aluminium alloy. They have capacities of 42, 74 and 110 cu. ft respectively, and each has the standard filling aperture 9 in diameter and the standard discharge door 34 in by 14¾ in. Specially designed gaskets are incorporated in both filling apertures and discharge doors to ensure that the sealing shall be dust and weathertight. Any of the bins can be lifted by crane, stillage or pallet truck or fork-lift truck, and they can be stacked, one on another, in a free-standing stack.

For filling with most granular materials it is only necessary to use a simple filling spout, but with very fine powders it may be advisable to use a Tote spinner head and jolter. The spinner head throws the material to the sides of the bin, forming a level load, and the jolter vibrates the bin once every 3 seconds to ensure capacity packing. Batch weighing equipment can be incorporated in filling arrangements.

When sealed the Tote bin is completely weathertight, and any number of bins can be stored as required, under cover or outdoors, without risk of damage to the contents by weather or vermin, or loss by evaporation.

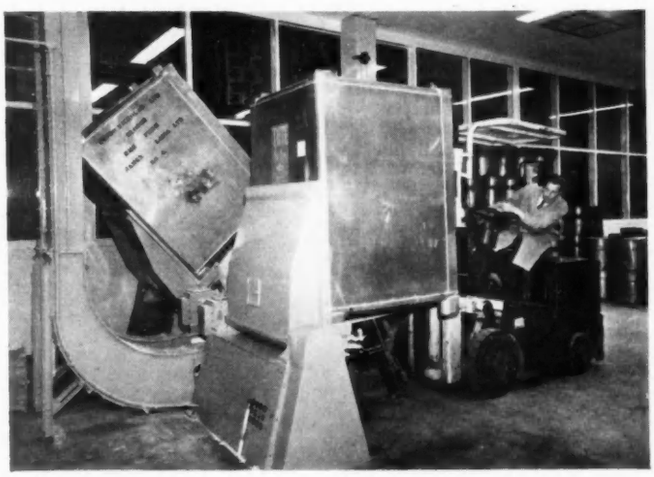
When it is required to empty a bin a fork-lift truck or other lifting medium is used to place it on a Tote tilt, which inclines it to an angle of 45°. A key is then inserted through the tilt unit and the discharge door is opened, allowing the material to flow. Specially designed gaskets ensure that there is no blow-back. An Archimedean screw type of discharge unit also is available, and vibrators can be fitted to either type to ensure complete discharge of fine powders. A further modification to which the system lends itself is weighing machine control. One or more Tote tilt units can be mounted on weighing platforms, and the scales can be arranged to stop the screw feed motor when a pre-determined weight of material has been discharged. Blending of two or more materials can be accomplished by this means. Fully flame-proofed equipment is available if the materials being handled give off inflammable fumes.

A typical Tote system installation is that used in the new factory of Aspro-Nicholas Limited, Bath Road, Slough. Some 10 tons of fine chemicals are received weekly at this factory from Monsanto Chemicals Limited, Ruabon, together with 2 to 3 tons of starch from James Laing and Son Limited, Trafford Park, Manchester. In both cases the suppliers deliver the goods in Tote bins by road transport. Fifty bins, of 74 cu. ft capacity each, are used, and there are two tilt units for discharging the contents to process machines. Each bin carries about 2,400 lb of the fine chemicals or 25 cwt of starch.

On receipt the contents of each bin are sampled by the laboratory, and the bin goes into a "quarantine" storage area until laboratory clearance is given. When cleared the bin is taken by fork-lift truck to the manufacturing department, emptied, and then returned to the storage area. There it is checked, sealed and re-loaded on to a road transport vehicle for return to the material supplier.

Material is stored in the bins. A sample is taken for laboratory checking, and the bins are released to the manufacturing department when the laboratory has declared the contents to be acceptable.

Several advantages have resulted from the use of the Tote system. No packing materials are now required; previously the main raw material was delivered in non-returnable 10 lb bags, 12 bags being packed in a returnable wooden case. One Tote bin replaced 240 bags and 20 cases. Less space is taken up by the Tote bins, and more material is transported on every vehicle journey; this has reduced transport costs by about 33⅓ per cent. Less labour is needed both for filling and emptying the containers, internal handling time has been reduced, and storage space is used more economically.



A fork-lift truck places the bin on a tilting discharger, and the contents are fed automatically to an elevator.

Operation and Maintenance

OPERATING A ROTARY SCREW COMPRESSOR

Determining the Most Suitable Rotor Profile

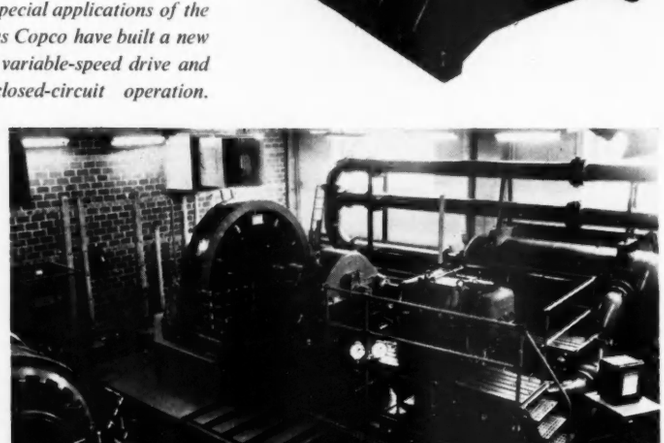
In the last ten years a considerable amount of development has been done by Svenska Rotormaskina AB on the screw-type compressor developed by the Swedish Professor A. Lysholm in 1934 and, in particular, the question of the most suitable rotor profile has been investigated. Operating experience has also been gained, under normal working conditions, on two compressors built by Atlas Copco A.B., Stockholm 1, and installed at Kiruna iron-ore mines in northern Sweden.

The Lysholm-type compressor, shown in the illustration on this page, is a two-rotor machine of the positive displacement type, the rotor profiles consisting mainly of circular arcs. There are four lobes on the male rotor and six on the female, and the male rotor takes practically all the power required by the compressor; the female acting mainly as a slide valve, and so absorbing very little power. The rotors do not touch one another or the casing; the small clearances being fixed by gearing and, accordingly, there is no friction and no need for the lubrication of the rotors. A completely oil-free air or gas delivery is thus ensured. Because there are clearances there must be some leakage losses, but the compressor is run at high speed (in the larger sizes at 3,000 r.p.m., with four complete compression cycles per revolution), and the losses are kept down to an acceptable level.

In comparison with other compressors, the screw type has several advantages. It requires less floor space than a piston-type machine, and the foundations can be smaller and lighter, owing to there being no unbalanced forces. Oil-free delivery, already mentioned, is another useful feature in many cases and, since there are fewer parts in mechanical contact, the overall rate of wear is low. It follows from the type of construction that the compressor is not so sensitive to impure air as one of rotary-vane type or a piston. Cooling-water consumption is low, and much of the heat can be recovered for heating purposes. As a result of the high speed of operation, the cost of the electric-driving motor is lower, and its efficiency is high.

The Atlas Copco rotary-screw compressor is of the positive displacement type, one rotor functioning mainly as a slide valve.

For developing special applications of the compressor, Atlas Copco have built a new test house, with variable-speed drive and equipped for closed-circuit operation.



THE COMPRESSOR IN USE

Two identical two-stage Atlas Copco machines are installed at the Kiruna mines. They have a capacity of 5,500 cu. ft of free air each per minute at a maximum working pressure of 120 lb per sq. in. Each compressor has a separate electric motor-driven lubricating oil pump. The main drive is by an induction motor which is started direct on line, the motor being of 1,340 h.p. at 2,970 r.p.m. and running on 3,000 volt, 50 c/s current. Each compressor consists of separate low-pressure and high-pressure stages, with the common driving motor between them, direct-coupled from the shaft extensions. Water jackets are incorporated in the compressor casings, and the rotors are internally cooled by lubricating oil. Intercoolers and aftercoolers are fitted.

Single-step unloading is incorporated, that is, the compressor can operate either on a full load or on no load, unloading taking place by opening the discharge to the atmosphere and simultaneously choking the intake pipe. When unloaded, the compressor operates between pressure limits of about 1·4 and 14 lb per sq. in absolute. Automatic controls protect the equipment by stopping the drive motor, in the event of lubricating-oil failure or low pressure, cooling water failure, excessive air temperature at the high-pressure suction or delivery, or electrical overload. When starting, the oil and cooling water pumps are run first, and then the main driving motor is run up to full speed, which takes about 8 seconds. Loading is then carried out manually and an interlock prevents the compressor from being started on load.

OPERATING EXPERIENCE

Experience has shown that the compressor can be silenced quite simply to a level which is acceptable in industry, and that very little attention is required while it is running. One of the Kiruna compressors ran for 5,300 hours, of which 4,700 hours were on load, and the other machine operated for 4,600 hours, with 4,200 hours on load. The delivery pressure is between 105 and 115 lb per sq. in, with an intake pressure which is normally 13·7 lb per sq. in absolute, the plant being 2,000 ft above sea level.

As the speed of the machine is relatively high, it might be thought that the risks of damage through mishandling would be considerable, but experience has proved the reverse. Even when a mishap did occur, as during the run-in of one compressor, the consequences were not very serious. A mechanical fault prevented the throttle on the suction side from opening when the machine was loaded automatically, and it operated between the limits of 1·4 and 120 lb per sq. in, which caused it to get very hot at the high-pressure stage. The thermostat which should have cut out the motor did not operate, and the overheating caused the rotors to expand, the sealing strips on the rotor tips being partly worn off. After the machine had cooled down, it would still work, although at reduced efficiency. The sealing strips were then renewed, which only caused a short interruption in service, and the compressor operated again quite satisfactorily.

TESTING

Operating experience has shown the rotary-screw compressor to be quite satisfactory for many applications, and Atlas Copco have a series of two-stage machines available, delivering from 5,500 to 19,500 cu. ft of air per min at 120 lb per sq. in, depending upon the size and speed of operation.

For special operating conditions, development work on the compressors is necessary and, for this purpose, Atlas Copco have added a special test house to their testing facilities for large screw compressors. An interior view of this test house, which is provided with variable-speed drive and closed-circuit operation, is shown in the illustration above. A d.c. motor of 2,000 h.p. drives the compressor through a gearbox, and testing can be carried out at various speeds. Close-circuit operation is employed, and the high and low-pressure stages are tested independently. Air from the compressor passes through a choke valve which sets the testing pressure, and then through a cooler, and so back to the compressor inlet. The closed circuit allows the compressor to be run at different pressure levels, and by changing the system from an external compressed-air source, the machine can be run at increased pressures. Similarly, the system lends itself to the use of gases other than air. A small vacuum pump enables the system to be put under negative pressure when required.

SWITCHGEAR IN THE TROPICS

To discover the effect on outdoor switchgear of tropical weather, the Brush Electrical Engineering Company Limited, Loughborough, have had two of their units tested severely over a period of five months, thus putting these machines through the equivalent of about five years of normal operation in the field. The tests, carried out in the tropical laboratory of the Yorkshire Switchgear and Engineering Company, provided a series of atmospheric cycles far more severe than would be encountered in actual service.

The tropical laboratory is about 10 ft square and 8 ft high, and has an air-conditioning plant which controls temperature and humidity over wide limits. Water sprays are provided to simulate rainstorms, and high-voltage bushings are built into the chamber walls to enable overvoltage tests to be carried out with the apparatus in its test position. Any cycle of atmospheric conditions can be arranged and repeated under automatic control. When the Brush units were tested, the average daily atmospheric cycle was:

Maximum temperature ..	40° C for 2 hours
Maximum relative humidity	100 per cent for 8 hours
Minimum relative humidity	50 per cent for 2 hours
Duration of tropical storm	Half an hour at 54 in per hour
Minimum temperature ..	6° C
Maximum temperature change	34° fall in half an hour.

A view of one of the Brush units under test in the laboratory is shown in the illustration.

Both the units under test, a switch fuse type HF11 and a high-voltage outdoor oil switch type OJ11, passed the test successfully. The HF11 switch fuse is designed for use on 3·3, 6·6 and 11 kV systems, for both indoor and outdoor applications. For outdoor purposes, it is fully weatherproofed. The same voltages are covered by the OJ11 outdoor unit, and this apparatus can be used singly or in multiple arrangements to form a complete switchboard.

Weatherproofing of a Brush switch unit is tested under simulated conditions more severe than would be met in tropical service.

Construction

CORRUGATED ROOFING GIVES VENTILATION AND LIGHT

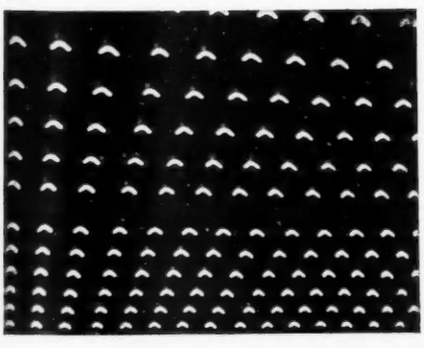
A new building material, which provides light and ventilation, has now been launched commercially on the market. Known as Ventrex, the product is a louvred corrugated sheeting through which can penetrate light and—more important—fresh air while excluding rain and snow, even in high winds.

The inventor of this remarkable product is a farmer, Mrs. I. V. Dawson, of Broyle Place, Ringmer, Sussex. On her own farm in Sussex, Mrs. Dawson has used Ventrex for her barns, cowshed and piggeries housing over 300 occupants. In the latter case, although the special sheets have only been used as "windows" in the existing roof, the ventilation provided has completely removed all trace of ammonia and other fumes. Ideally, of course, the Ventrex sheets could be used for completely roofing a building, but they can as well be adapted for existing buildings where they may be fitted over larger corrugations of, say, asbestos sheets.

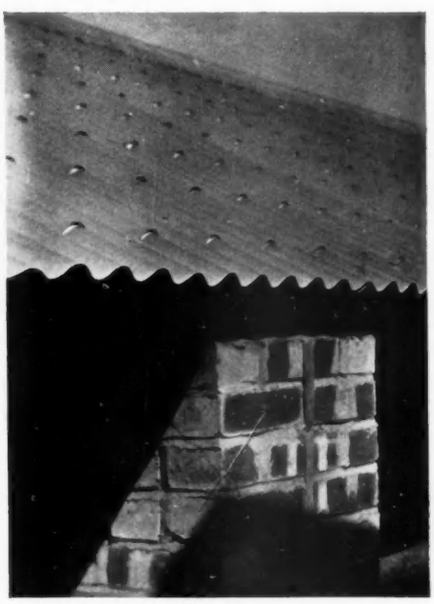
Ventrex roofing is now being made in Galvatite, the John Summers's galvanised steel sheet made by the continuous galvanising process. This method of galvanising, pioneered in this country by John Summers and Sons Limited, Shotton, provides a coat of zinc uniform in thickness and ensures the maximum adhesion between the zinc and the steel base, thus giving the longest possible life for the galvanised sheet.

Although the use of Ventrex has so far been almost entirely confined to agriculture, factories and stores, its industrial and general potential is extremely wide. Sample quantities are already being shipped to Africa for housing purposes, and its value in industry where noxious fumes are present is being widely recognised.

Further details can be obtained from Ventrex Roofing Ltd., 5 Fenchurch Street, London, E.C.3.



(*Above*) *Interior view of Ventrex roofing showing ventilation louvres.*



(*Right*) *The exterior view of the roofing shown ins alled on a Sussex farm.*

CONCRETE PRACTICE COURSE

Practical courses in the making and placing of concrete, backed by instruction in the underlying principles of this type of work, have been available at many technical colleges during the last three years.

Such courses of practical instruction are of considerable importance to the building and civil engineering industries, and already many firms have benefited from encouraging their staff to undertake this course of training.

Many technical colleges in England, Scotland, Wales and Northern Ireland are offering the concrete practice course in one or two grades, during the 1958-59 session. Anyone interested in attending these courses may obtain the address of the most convenient college and additional information from the Cement and Concrete Association, 52 Grosvenor Gardens, London, S.W.1

Continuing **Construction**

Auger type earth boring machine in operation under the British Railways Western Region main line, near Banbury station.

AUGER TYPE EARTH BORING MACHINE

With the aid of an auger type earth boring machine 100 ft of 12 in pipe was laid under the main Banbury to Paddington railway line in a matter of hours without any disturbance to railway traffic.

The auger type machine is a recent acquisition of William Press and Son Limited, 22 Queen Anne's Gate, London, S.W.1. The machine which is one of two of its size operating in this country, can make boring for a steel sleeve or pipe up to 42 in in diameter and virtually to any length. The greatest asset of the machine is that it can bore under any public thoroughfare, railway or canal, without interrupting the traffic in any way. The reason for this is that the machine is in no way a "thrust bore." The cutting head is only approximately 1 in in front of the actual sleeve, consequently as the hole is being cut so the space is immediately replaced by a steel sleeve, thereby ensuring safety and obviating any chance of a cave-in.

The principle of the machine is that the sleeve itself contains the auger which brings the excavated soil—removed by the cutting head—through the sleeve and out under the machine. The forward movement is obtained by a power winch situated on the front of the machine pulling on a "dead man" anchor near the cutting face. As the auger and cutting head rotate, power is supplied to the winch and the casing is pushed into the hole. In this way the machine can be operated without disturbance of railway, road or waterway traffic, and work can be carried out speedily, economically and safely under almost any conditions.

The illustration shows the machine in action during working conditions under the Western Region main line railway, outside Banbury station, where a 16 in diameter sleeve was used for the laying of a 12 in main, the work being carried out for the Southern Gas Board.

Engineering at Home

FAST RISING FLATS

One of London's largest multi-storey housing contracts has now been completed by Wates Limited, Norbury Road, London, S.W.16. The contract, which is for 1,035 dwellings in flats and maisonettes, has been completed five months ahead of schedule. It is part of a larger London County Council scheme of 1,870 dwellings on a site covering nearly 100 acres, lying between Richmond Park and Roehampton Lane in the south-west corner of Wimbledon Common. The overall density is 28 dwellings (100 persons) to the acre.

The Wates contract, valued at £2,700,000, is for three groups of high buildings consisting of five 11-storey maisonette slab blocks, with 75 maisonettes to each block, on the Downshire site, and two separate groups—15 in all—of 12-storey point blocks, with 44 flats in each block, on the Mount Clare and Hartfield sites. The point blocks contain two 2-roomed flats and two 3-roomed flats on each floor, with lifts that stop on alternate floors. The maisonettes are served by access galleries, a single public staircase, and two lifts which also stop at alternate floors.

A large amount of pre-planning was done prior to the acceptance of the contract. For example, the problem and the consequences of getting electric mains to the site were fully examined. It was decided, in regard to the supply and distribution of electricity, that the cost involved could be borne provided every possible item of equipment was power-driven. The installation has, in fact, been used to the maximum for the operating of tower cranes, hoists, mixers, and numerous hand tools.

The point blocks were designed with normal reinforced-concrete frame structure. The maisonette blocks were designed with a combination of reinforced-concrete frames and load bearing walls, the loads being carried down at ground level on to circular columns. In order to take full advantage of site erection techniques, such items as horizontal floor beams, balconies and staircases, were precast on the site, which considerably improved the speed of erection of the structures.

External scaffolding was dispensed with completely. For the erection of superstructures, prefabricated units comprising both guard rails and tow boards were bolted to precast beams while on the ground, and were lifted in that condition by crane in one operation.

The nature of the sub-soil gave rise not only to "ground heave" but also to the movement of the piles themselves, due to the plastic condition of the soil. The difficulties were met by increasing the pile depth. Forty-ton piles were necessary throughout—159 per point block, 292 per slab block.

Full heating in the living rooms and background heating in bedrooms is provided by convectors served with hot water from a fully automatic oil-fired boiler plant. Domestic hot water is obtained from the same plant by means of an indirect cylinder in each flat. The hot water for both services is pump-circulated to all blocks through an inverse ring-main distribution around the site. The boiler house is mostly below ground but its 121 ft high chimney can just be seen at the rear end of the second slab block on the right, shown in the illustration. The ventilation system consists of internal ductwork leading from all bathrooms and lavatories to extraction fans in the roofs. A similar system provides mechanical extract ventilation for each dwelling's drying cabinet.

Completed 5 months ahead of schedule, these buildings form part of a London County Council scheme of 1,870 *dwellings on a* 100 *acre site.*

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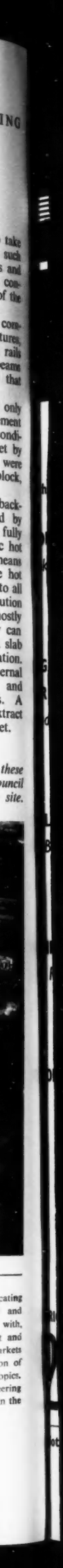
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